EVALUATION OF RESEARCH ACTIVITIES AT ASHUMET AND JOHNS PONDS

OCTOBER 1995
revised FEBRUARY 1996

Submitted to:

Ashumet-Johns Pond TAG Coalition Committee
East Falmouth, Massachusetts

Prepared by:
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EXECUTIVE SUMMARY

This report reviews the results of a two-year study of Ashumet and Johns Ponds in Falmouth and Mashpee, Massachusetts conducted by the National Guard Bureau. The study was planned to address residents' concerns regarding the potential effect of the Massachusetts Military Reservation on Ashumet and Johns Ponds. The National Guard Bureau conducted the study based on extensive input from local residents. The study includes tasks to collect data to characterize ground- and surface-water quality, sediment quality, storm-water quality, benthic algae, and bioaccumulation of chemicals in fish and mussels.

The Ashumet and Johns Ponds Study followed recommendations previously prepared by the Johns Pond Ashumet Pond Task Force, a group of local environmental specialists and citizens. The Task Force recommendations formed the basis for a detailed Sampling and Analysis Plan prepared for the National Guard Bureau. The results of the Ashumet and Johns Ponds Study was reported in a series of quarterly data reports and two annual reports which summarized data and provided some analysis and interpretation. We reviewed the Ashumet and Johns Ponds Study documents as well as Remedial Investigations Reports for the closely associated Ashumet Valley Groundwater Operable Unit and the Southeast Region Groundwater Operable Unit. In addition, we reviewed prior independent studies of Johns and Ashumet Ponds as well as other National Guard Studies addressing Ashumet Pond and the area ground water.

The studies were reviewed from two aspects. The first was a review to compare the work completed with the recommendations of the Johns Pond Ashumet Pond Task Force and the detailed specifications of the Sampling and Analysis Plan. The second was to evaluate the information from the standpoint of completing ecological and human health risk assessments.

In general, the studies followed closely the letter of the Task Force recommendations and Sampling and Analysis Plan insofar as the data collected. A large quantity of information was gathered over the course of the two-year study with only a few

deviations from the recommendations and plans. Departures from the recommendations or plans included failures to meter seepage across the lake beds and install automatic equipment for storm water sampling. The number or type of samples collected proved inadequate for lake trophic state indicators, benthic algae, volatile organic compounds in fish and mussel tissue, and chemical concentrations in sediment. Several of these deviations are significant in that the pond sediments and benthic fauna are poorly characterized but are the media within the ponds most likely to show evidence of volatile organic compound contamination.

Although the study closely followed the recommendations of the Task Force for data collection, we found the Ashumet and Johns Ponds Study reports lacking insofar as analysis and interpretation of the data were concerned. A considerable quantity of information has been collected and is provided in these reports. However, the reports are primarily a recitation of the data. Omitted were several important analysis tasks recommended by the Task Force including developing nutrient and hydrologic budgets for the ponds, and determining the quantities and locations of ground-water and ground-water contaminant discharge to the ponds. Overall, the spirit of the Task Force's recommendations—to develop a good understanding of the potential effects of the MMR on the ponds—has not been fulfilled.

An accepted means to understand the health and safety of the ponds is a risk assessment conducted in accordance with U.S. EPA guidelines. We reviewed the adequacy of the information collected by the National Guard Bureau (NGB) to support future ecological and human health risk assessments of Ashumet and Johns Ponds. The various reports reviewed do not provide information in a risk assessment framework although the information provided in them is useful to support risk assessments of the ponds. We therefore reviewed and organized the data from these studies using current EPA ecological and human health risk assessment paradigms and EPA guidance documents. This approach allows for a complete, systematic review of the available data to support risk assessments consistent with current regulatory guidance. Our approach was to describe the components of ecological and human health risk assessment, assess the sufficiency of the existing data to meet the requirements of each component, and provide recommendations regarding the type of data that may fill the data gaps.

Sufficiency of studies to conduct human health risk assessment

There are several data gaps that need to be filled before a site-specific human health risk assessment can be completed. Scenarios which could be considered in a site-specific human health assessment include the use of the ponds for recreational activities and fishing. To complete such an assessment, we recommend the following:

- Collect additional shoreline sediment and surface-water data to provide more information on contaminant distribution, magnitude of contaminant concentration, and frequency of detection at the site.

- Develop information to characterize potential human exposures through a review of local maps and area zoning information, a site visit, and interviews with local residents who may use the site recreationally.

- Identify the fate and transport mechanisms of the chemicals of concern, including bioaccumulation into edible fish.

- Consult toxicity factors developed and approved by the U.S. EPA to determine which of the potential chemicals of concern at the site meet U.S. EPA-approved toxicity factors. The toxicity of each of the potential chemicals of concern should be reviewed, and toxicity profiles written.

We feel that these additional data will provide enough information to assess human health risks in Ashumet and Johns Ponds. Without the additional sediment and surface-water data, a limited and more uncertain assessment will result.

Sufficiency of studies to conduct ecological risk assessment

We believe that the data collected during this study provide a good basis for assessing the risk of eutrophication in the two ponds and additional data analysis should be completed to develop such an assessment. There are significant gaps that would need to be filled before site-specific ecological risk assessments could otherwise be completed, however. The data provide a basis for preliminary risk assessments which are included in the SERGOU and AVGOU Remedial Investigation reports. However, it appears that in the absence of more complete data, many conservative assumptions were required and have diminished the certainty of the assessment. Moreover, the preliminary risk assessments appear not to have included community participation and important community concerns are not addressed. One of the most worthwhile aspects of the exercise

of a preliminary risk assessment is defining appropriate assessment endpoints that reflect the community's concerns and thereby identifying data gaps that need to be filled. This opportunity appears to have been missed in preliminary risk assessments completed to date.

A particularly critical step in the risk assessment is the definition of assessment endpoints. Assessment endpoints are a direct reflection of the aspects of the ponds it is desired to protect, for example, sport fishing and the protection of wildlife. Under the current EPA risk assessment protocol, assessment endpoints are developed cooperatively with the input of the community, government agencies, responsible parties, and other potentially affected parties. Such a process, and any necessary follow-up data collection, is essential to the successful completion of the Ashumet and Johns Pond Study. We have identified several possible assessment and measurement endpoints which may be representative of community concerns. Examples include:

Assessment Endpoint	Suggested Measurement Endpoints
Protection of pond trophic status	increased phytoplankton growth
	decreased levels of dissolved oxygen
Protection and preservation of fishery	bioaccumulation of chemicals in fish
	fish pathology
	preservation of food base
	low levels of dissolved oxygen in water column
Protection of wildlife	bioaccumulation of chemicals in wildlife
	wildlife pathology
	preservation of food base
Protection of recreation	preservation of swimming, boating, fishing

Assuming that these assessment and measurement endpoints are representative of the endpoints that will be identified by the community, the following data are required to complete a site-specific ecological risk assessment:

- Develop a supplementary sampling and analysis work plan to identify additional sediment and surface-water stations, based on potential ecological exposures.
- Research the toxicity, bioaccumulation, and persistence of the detected chemicals to determine their potential for affecting ecological components.

- Conduct a literature review to provide background information on the plant and animal species expected to occur at the ponds and in proximate areas; the use of the general area by migrating or over wintering species; and the general distribution and abundance of species in the area.

- Conduct a biological/habitat survey of the ponds to identify the nature and composition of aquatic and terrestrial animal and plant communities in the vicinity of the ponds. The survey should identify:

  major flora in the ponds and adjacent areas;

  fish species in the ponds; and,

  amphibian, mammal and bird species;

  habitat types associated with the pond such as bordering wetland, vegetated beds, open or vegetated banks, et cetera.

- Based on the results of these surveys, identify sensitive, threatened and endangered species.

- Based on the results of the surveys, characterize the food-web dynamics of the ponds.

- Conduct a benthic invertebrate survey to characterize the individual species and quantities present in each pond.

- Research acute and chronic toxicity studies for both fish and wildlife for chemicals detected. This information should help provide perspective on the critical endpoints associated for each chemical.

- Develop a site conceptual model after the information identified above has been obtained or collected.

- Research the toxicological effects of the chemicals of concern. The results of this research should be chemical profiles which discuss the types of ecological effects which may occur and at what level or dose these effects are anticipated to occur.

- Select ecological endpoints for each receptor. The endpoints should reflect the stated goals of the assessment. A table of reference doses and associated effects should be developed for both fish and wildlife receptors.

Without such information, a site-specific ecological risk assessment is not possible. We feel that such a risk assessment is important to provide reliable and realistic estimates of ecological risk for Ashumet and Johns Ponds.

Recommendations:

Our overall recommendations to the Ashumet-Johns Pond TAG Coalition Committee are the following:

- The National Guard Bureau should be encouraged to prepare a summary report that emphasizes analysis and interpretation of the data collected during the Ashumet and Johns Pond study.

- The National Guard Bureau should be encouraged to complete a systematic, site-specific risk assessment in accordance with U.S. EPA guidelines. We recommend site-specific risk assessments to provide a basis for meaningful and reliable risk management decisions.

- The risk assessment should include community participation in the definition of risk assessment endpoints to ensure that those endpoints properly reflect community concerns.

- To the extent that the risk assessment process indicates gaps in the existing data, those gaps should be filled.

- There should be a continuing program to monitor the quality of ground water that discharges into the ponds.

- There should be a continuing program to monitor the water quality and trophic state of Ashumet and Johns Ponds.

EVALUATION OF RESEARCH ACTIVITIES AT ASHUMET AND JOHNS PONDS

1. INTRODUCTION

This report reviews the results of a two-year study of Ashumet and Johns Ponds in Falmouth and Mashpee, Massachusetts conducted by the National Guard Bureau (NGB). Ashumet and Johns Pond are kettle-hole lakes situated in the glacial outwash plain of southwestern Cape Cod (Figure 1). The ponds lie directly to the south of the Massachusetts Military Reservation (MMR), a complex of military facilities that includes Otis Air Force Base. Over many decades, disposal and spills of solvents, fuels, and other materials has led to soil and ground-water contamination on the MMR. Plumes of contaminated ground water have migrated from the base into neighboring areas. In addition, the MMR sewage treatment plant discharged treated wastewater to the subsurface, leading to a plume of sewage-contaminated ground water that has also traveled off the base. Ashumet and Johns Pond receive both surface and ground-water inflow potentially affected by MMR contamination, raising the concern of residents and other parties as to the potential harm to the ponds.

The Ashumet and Johns Pond Study was planned to address residents' concerns regarding the potential effect of the MMR on Ashumet and Johns Ponds. The study was conducted by the National Guard Bureau based on extensive input from local residents. The study includes tasks to collect data to characterize ground- and surface-water quality, sediment quality, stormwater quality, benthic algae, and fish. This report provides a review of these various studies conducted as a part of the Ashumet and Johns Pond Study.

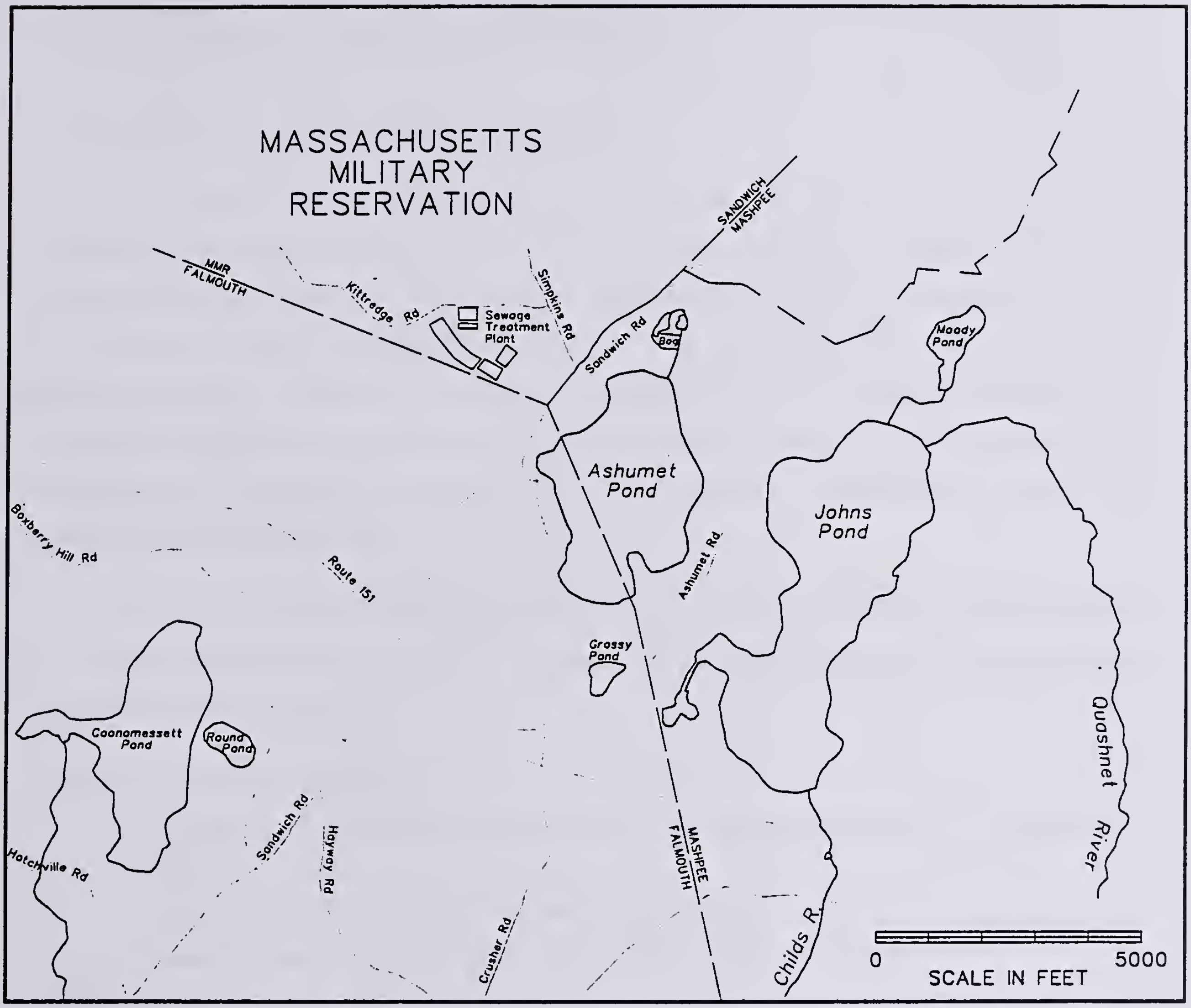

Figure 1

Location Map for Ashumet and Johns Ponds

2. REVIEW OF RECOMMENDED WORK PLANS

2.1 JOHN'S POND ASHUMET POND TASK FORCE

2.1.1 Summary of Task Force Recommendations

The John's Pond Ashumet Pond Task Force is a group of fifteen Cape Cod scientists, engineers, and other specialists convened by the Association for the Preservation of Cape Cod to provide recommendations to the National Guard Bureau for investigations of Johns and Ashumet Pond. In a series of meetings in late 1991 and early 1992, the task force developed a set of recommended investigation tasks that would address public concerns about the health and safety of Ashumet and Johns Ponds. These recommendations formed the basis of the eventual study plan developed by the National Guard Bureau for its study of Ashumet and Johns Pond.

At the conclusion of its deliberations, the Task Force recorded its recommendations in a written report (APCC, 1992). The scope of studies proposed by the Task Force consisted of the following:

Hydrogeologic Investigation

- Definition of water-table configuration and flow paths into and between ponds.
- Definition of vertical ground-water flow patterns.
- Measurement of seepage into and streamflow out of the ponds.

Water Quality Sampling

- Collection of quarterly surface-water samples timed to correspond to lake stratification cycles.
- Collection of ground-water samples in residential areas and where plumes discharge to the ponds.

Sediment Sampling

- Sediment samples in deep-hole and low-energy depositional areas in ponds and in drainage swales.
- Testing for pesticides in sediment.

Storm Water Sampling

- Review current storm water sampling program, especially as it relates to timing of samples during storm events.

- Define MMR contribution through storm water samples and analyze correlation between precipitation intensity and storm water discharge.

Sampling of Benthic Algae

- Assess taxonomic composition and density of benthic algae and analyze correlation with plume constituents.

Bioaccumulation Investigation

- Histopathologic examination, chemical testing, and tissue bioassays of fish and invertebrate samples.

The Task Force also recommended a follow-up investigation of rare and endangered species if the studies above showed that the plumes are such that they could affect those species.

2.1.2 Review of Task Force Recommendations

The activities recommended by the Task Force constitute a thorough and detailed examination of Ashumet and Johns Ponds. The recommendations are given in the form of a generalized outline, leaving the development of a detailed scope of work to the Guard Bureau. This was an appropriate approach in our opinion in that the development of a detailed sampling and analysis plan was best left to the contractors retained by the National Guard Bureau. The burden of developing a plan meeting Superfund program requirements thereby fell to experts familiar with those requirements. Moreover, the contractors would later be working to a plan of their own development, but within some broad guidelines established by citizen advisors.

The Task Force recommends various kinds of data analysis. These include the development of hydrologic budgets for the ponds, analysis of the correlation between rainfall intensity and storm water runoff, and correlation of benthic algae data with nutrient loading and plume constituents. Moreover, there is an implicit charge to assess risk, determine trends and impacts, and otherwise analyze the collected data. A framework for this analysis is provided in the report through a listing of 43 "Questions Relating to John's/Ashumet Pond Field Investigations" as well as Appendix 2, Detailed Summary of Issues/Questions Driving Development of Scope of Work. However, the Task Force did not make an explicit recommendation for an overall reporting and data analysis task. Because the Guard Bureau failed to follow through in the spirit of the Task Force's

recommendations, it now appears that it would have been beneficial to have made this an explicit recommendation. As it is, the Ashumet and Johns Ponds Study has resulted in a series of quarterly and annual reports that are primarily data compilations and summaries, but which provide little insightful analysis into the ponds, their interaction with ground-water contaminant plumes, and ecological and human-health risk.

2.2 ASHUMET AND JOHNS PONDS SAMPLING AND ANALYSIS PLAN

2.2.1 Summary of Sampling and Analysis Plan

The Sampling and Analysis Plan provides a detailed specification for the various measurements, samples, analyses, and other activities to be completed as a part of the Ashumet and Johns Ponds Study. The plan was first issued in draft form in September 1992 and then in final form in August 1993 (HAZWRAP, 1992, 1993). The two years of studies conducted under the Sampling and Analysis Plan are reported in the 1993 and 1994 Annual Reports (HAZWRAP, 1995a, 1995b). The reports provide data for various parameters including: toxic and conventional pollutant concentrations and accompanying chemical/physical measurements in ground water, surface water, storm water, sediment, fish, and mussels; biological characteristics such as chlorophyll-a, phytoplankton and periphyton abundance and general taxonomic composition, and several physiological characteristics of fish and mussels from each pond.

The Plan indicates that "One of the most important parts of the analyses was to ensure that the revised scope of work resulted in the proper kinds of analyses—incorporating sufficient quality assurance/quality control (QA/QC) samples—to support both human health and ecological risk assessments" (HAZWRAP, 1993, pg. 1). The emphasis this document places on risk assessments is highly appropriate and consistent with the desires of residents as expressed by the Ashumet and Johns Pond Task Force. Moreover, many of the parameters measured under the Sampling and Analysis Plan may have substantial use in human health and ecological risk assessment. However, neither the Sampling and Analysis Plan nor the Annual Reports provide a general risk assessment framework from which to evaluate the use of these data. Particularly, the documents do not reference or incorporate current EPA guidance for human health and ecological risk assessment. The omission of a systematic risk assessment framework from the Guard

Bureau program may present a significant flaw in the Ashumet and Johns Pond Study. Because of the importance of this aspect of the study, it is discussed separately in Section 4 below. As background to that discussion, this section describes the program laid out in the Sampling and Analysis Plan.

The Sampling and Analysis Plan includes, in addition to an introduction and background description, sections that address: sampling objectives, sample location and frequency, field feature identification (a sample identification and numbering scheme), laboratory analytical program, sample handling and analysis, possible additional activities, and documentation and reporting. The plan is organized around the following major technical activities:

1. Ground-Water Quality Sampling
2. Surface-Water Quality Sampling
3. Sediment Sampling
4. Storm Water Sampling
5. Benthic Algae
6. Bioaccumulation (Fish) Studies
7. Bioaccumulation (Mussel) Studies

In addition, the plan discusses hydrogeologic investigations to be undertaken under the Installation Restoration Program that relate to the Ashumet and Johns Ponds Study.

The sampling objectives represent an important touchstone in evaluating the results of the study. The Sampling and Analysis Plan gives the objectives shown in Table 1 for the major technical activities. These sampling objectives, and the detailed activities specified under the plan, are based very closely on the recommendations of the John's Pond Ashumet Pond Task Force.

The Sampling and Analysis Plan includes detailed specifications for the type of data to be collected and the locations and frequency of collection. The data collection activities are summarized in Table 2.

Table 1

Objectives from Sampling and Analysis Plan

Activity	Objectives
1. Ground-Water Quality	Determine points where plumes enter the ponds, including vertical profiles of the plumes.
2. Surface-Water Quality	Characterize the water quality of the ponds. Combine with hydrogeological data to gain better understanding of internal and external forces on water column processes.
3. Sediment Sampling	Characterize contaminants found in the surface sediments in low energy depositional areas, potentially link them to contaminant sources, and determine the potential for contaminated sediments to leach contaminants into the pond water. Aid in understanding the benthic zones' importance in internal loading to the water column, as well as effects of localized external loading. Develop external loading history to each pond.
4. Storm Water Sampling	Determine the constituents of storm water runoff to the ponds and determine the percentage of pollutant loading to ponds from storm water runoff.
5. Benthic Algae	Characterize the current composition of algal species in the ponds and determine the effect discharge of plumes has had or may have on algal species. Provide a baseline against which future changes in the ponds can be measured.
6. Bioaccumulation (Fish) Studies	Determine whether evidence of contaminant exposure is present in vertebrate species in the ponds and determine whether contaminants bioaccumulate in tissues of fish species in the ponds.
7. Bioaccumulation (Mussel) Studies	Determine whether contaminants bioaccumulate in tissue of benthic filter-feeders

Table 2. Summary of Data Collection Proposed under Sampling and Analysis Plan

Parameter or Activity	Sampling Locations	Sampling Frequency
GROUND-WATER QUALITY SAMPLING		
VOCs, SVOCs, Pesticides, Metals	Wells to be installed	Every 6 months
Nutrients	Same	Every 6 months
SURFACE-WATER QUALITY SAMPLING		
General water-quality parameters	4 stations in each pond	Quarterly (seasonal)
CLP parameters	Same	Each summer and winter
Cranberry bog and Ashumet near-shore area	Under RI	Under RI
SEDIMENT SAMPLING		
Pond sediments	4 stations each pond	3rd Quarter 93
Catch basins, road drains, stream deltas	2 stations in each pond plus unspecified off-pond locations	3rd Quarter 93
Grain size	All samples	3rd Quarter 93
CLP parameters	All samples	3rd Quarter 93
Nutrients	All samples	3rd Quarter 93
STORM-WATER SAMPLING		
Storm water outfalls	SD-1, SD-2, SD-3, SD-4	Automatic samplers
Correlation between storm intensity and discharge to ponds	Same	Event based sampling
BENTHIC ALGAE INVESTIGATION		
Taxonomic identification and enumeration	6 stations in Ashumet Pond 4 stations in Johns Pond	Over 2 years
Field parameters including irradiance	Same	Over 2 years
FISH BIOACCUMULATION INVESTIGATION		
Macroscopic morphology	15-30 fish of 2 species from each pond	1st Quarter 93
Histopathology	Same	1st Quarter 93
CLP parameters	Same	1st Quarter 93
Lipids	Same	1st Quarter 93
Blood chemistry	Same	1st Quarter 93
MUSSEL BIOACCUMULATION INVESTIGATION		
CLP parameters	4 stations in each pond	3rd Quarter 93
Lipids	Same	3rd Quarter 93

2.2.2 Review of Sampling and Analysis Plan

In general, the Sampling and Analysis Plan is comprehensive with respect to the types of data collected although for certain parameters the number of stations and frequency of collection were spare.

The parameters that could have been anticipated to have required a greater frequency of sampling are those related to conventional water quality in the ponds. A previous study of Ashumet Pond by K-V Associates (1991) had included sampling as frequently as once per month during a one-year period in 1985 and 1986. The data, particularly phytoplankton distribution and abundance, showed significant variation between samples and indicated a dynamic system. The quarterly sampling employed in the Ashumet and Johns Ponds studies captures these variations poorly, diminishing the value of comparisons with the earlier K-V data.

As discussed in Section 4, the sediment data are insufficient for site-specific risk assessment. The sediment data prove to be significant inasmuch as this is perhaps the only medium, other than ground water, in which volatile organic compounds (VOCs) are likely to be identifiable. VOC detection in surface water is unlikely due to dilution and volatilization. Detection in fish is also unlikely because the volatile organic compounds of concern are known not to bioaccumulate.

The Sampling and Analysis Plan is generally deficient in specifying the types of analyses to be done and how those are to be reported. The plan follows the letter of the Task Force recommendations very closely, but fails to recognize the spirit of those recommendations insofar as answering the questions listed by the Task Force. Thus, the Sampling and Analysis Plan includes great detail on the field and laboratory activities, but provides almost no guidance on the mathematical, statistical, and other analyses to be performed. For example, a critical issue is the load of both conventional and toxic pollutants to the ponds. Yet, the Sampling and Analysis Plan provides no direction that water and mass balances should be constructed to define these loads. There are also references throughout the Plan to correlation between various environmental parameters, but no specifications as to the statistical or numerical analyses to be done to determine that correlation.

3. SUMMARY OF ASHUMET AND JOHNS PONDS STUDY RESULTS

3.1 STUDY RESULTS

The results of Ashumet and Johns Ponds study are reported in the following documents:

- Ashumet and Johns Pond Study, Quarterly Report No. 1. Hazardous Waste Remedial Actions Program, Oak Ridge, Tennessee. March 1993.
- Ashumet and Johns Pond Study, Quarterly Report No. 1, Addendum. Hazardous Waste Remedial Actions Program, Oak Ridge, Tennessee. April 1993.
- Ashumet and Johns Pond Study, Quarterly Report No. 2. Hazardous Waste Remedial Actions Program, Oak Ridge, Tennessee. July 1993.
- Ashumet and Johns Ponds Study, 1993 Data Addendum. Hazardous Waste Remedial Actions Program, Oak Ridge, Tennessee. February 1995.
- Ashumet and Johns Ponds, 1993 Annual Report (Final). Hazardous Waste Remedial Actions Program, Oak Ridge, Tennessee. June 1995.
- Ashumet and Johns Ponds, Year 2, Quarterly Report No. 1. Prepared for Hazardous Waste Remedial Actions Program. CDM Federal Programs Corporation, Oak Ridge, Tennessee. June 1994.
- Ashumet and Johns Ponds, Year 2, Revised Quarterly Report No. 2, April-June, 1994. Prepared for Hazardous Waste Remedial Actions Program. CDM Federal Programs Corporation, Oak Ridge, Tennessee. March 1995.
- Ashumet and Johns Ponds, Year 2, Quarterly Report No. 3, July-September 1994. Prepared for Hazardous Waste Remedial Actions Program. CDM Federal Programs Corporation, Oak Ridge, Tennessee. June 1995.
- Ashumet and Johns Ponds, 1994 Annual Report (Draft). Prepared for Hazardous Waste Remedial Actions Program. CDM Federal Programs Corporation, Oak Ridge, Tennessee. June 1995.

The quarterly reports and their addenda are data compilations without interpretative text. The 1993 and 1994 Annual Reports summarize the data in graphs and tables and provide interpretative discussion. These reports, however, are inaccessible to most readers. They are difficult, dense reading and highly technical. Moreover, they too are largely "data dumps" with little in the way of succinct, cogent interpretation or analysis.

3.1.1 Hydrogeological Characterization

The hydrogeological characterization is summarized in the Ashumet and Johns Ponds 1994 Annual Report, but more thoroughly presented in the Remedial Investigation reports for the Southeast Region Groundwater Operable Unit (SERGOU) and the Ashumet Valley Groundwater Operable Unit (AVGOU) (ABB, 1994, 1995). Because of the large size of the RI reports, the National Guard Bureau declined to provide us with copies but were able to borrow copies elsewhere.

The Remedial Investigation Reports and 1994 Annual Report (HAZWRAP, 1995b) identify several ground-water plumes as discharging to one or both of Johns and Ashumet Pond or of having potential to do so in the future (Figure 2):

- A plume of chlorinated solvent contamination originates from Fire Training Area 1 (FTA-1) somewhat northwest of the MMR wastewater treatment plant and Ashumet Pond. The plume has migrated about 3 miles to the south in the Ashumet Valley. The AVGOU RI found this plume to be present at elevations below the bottom of Ashumet Pond and thus unlikely to discharge into the pond.

- A plume of fuel-derived organic compounds originates from the Western Aquafarm, Fire Training Area 2 (FTA-2), and a rubble/debris landfill (LF-2) north of Ashumet and Johns Ponds. The plume discharges to the Cranberry Bog north and upstream of Ashumet Pond.

- A plume of chlorinated solvents and inorganic compounds originates from the Nondestructive Inspection Laboratory and other sources in the area of Storm Drainage Disposal Site 5 (SD-5) north of the ponds, has migrated to the north shore of Johns Pond, and discharges into the pond.

- A plume of fuel-derived organic compounds originates from the Petroleum Fuel Storage Area (PFSA) north of the ponds and migrates toward the ponds. The ground water from this area eventually discharges into Johns Pond, but the fuel-derived compounds degrade prior to reaching the pond.

- Ground water in the southeast region of the MMR is sporadically contaminated by solvents and other contaminants. This ground water discharges to Ashumet Pond and the Quashnet River.

The following plume is not discussed in detail in the 1994 Annual Report and RI Reports, but has significant potential to affect Ashumet Pond:

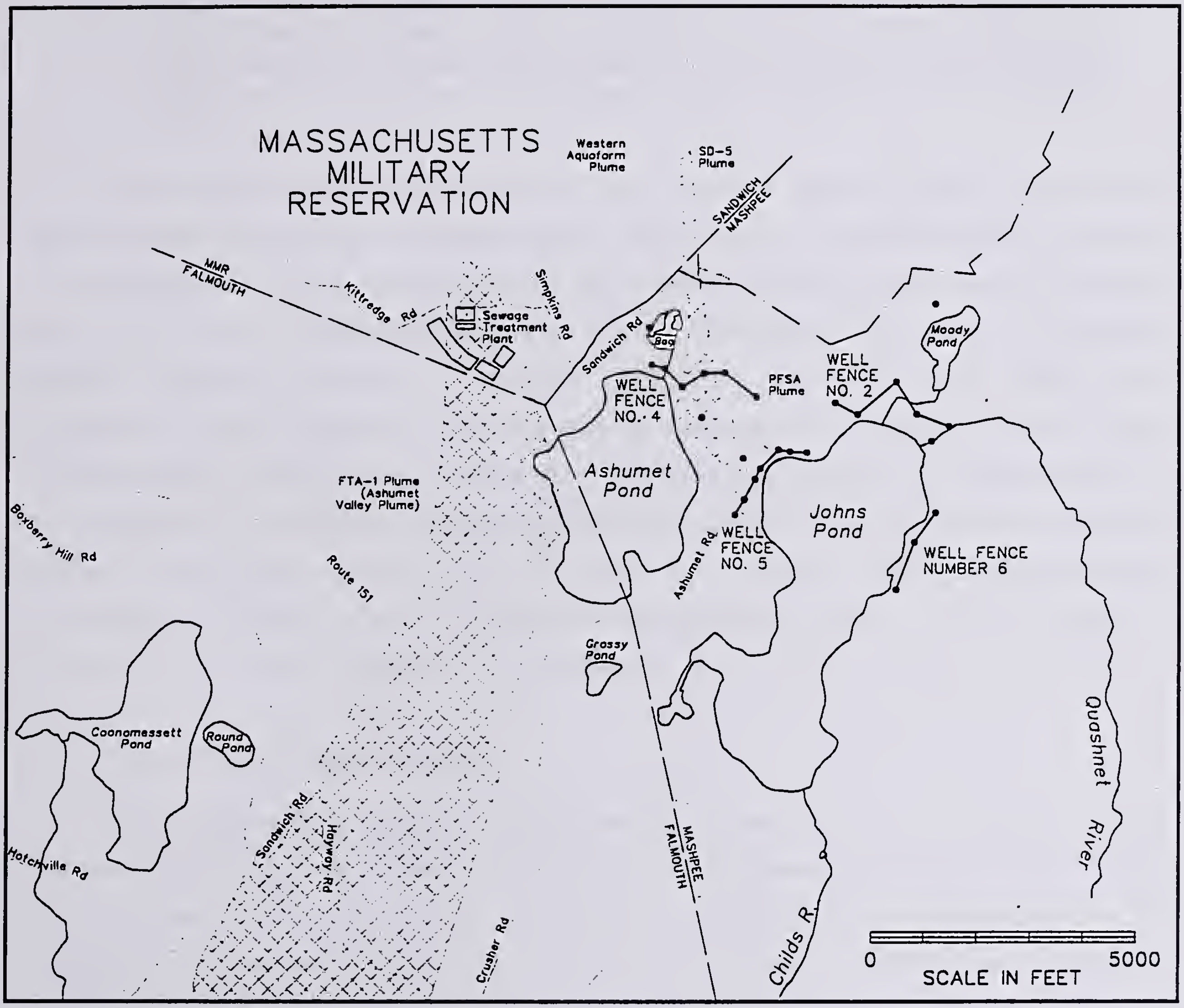

Figure 2

Plumes of Contaminated Ground Water
Near Ashumet and Johns Ponds

- A plume of sewage-contaminated ground water originates from the MMR sewage treatment plant (STP) northwest of Ashumet Pond and flows directly towards and discharges into Fisherman's Cove in the northwest part of the pond. Recent studies by the U.S. Geological Survey (Walter, 1995) have shown high concentrations of phosphorus within this plume, thus presenting the potential to increase the nutrient input and trophic state of Ashumet Pond.

The conclusions of the hydrogeologic investigations are that Johns Pond receives contaminated ground-water discharge from the SD-5, PFSA, and Southeast MMR; and that the Cranberry Bog north of Ashumet Pond receives contaminated ground-water discharge from the Western Aquafarm/FTA-2/LF-2 plume. The plume of sewage-contaminated ground water also discharges to Ashumet Pond. The AVGOU RI report (ABB, 1995) describes a ground-water flow model to assess the potential for the Ashumet Valley Plume (FTA-1 plume) to discharge to Ashumet Pond following changes in ground-water flow after the cessation of wastewater discharges from the STP and the commencement of a ground-water pump-and-treat system at the CS-4 plume to the west. Under conditions of high ground-water recharge at the CS-4 ground-water treatment system, the FTA-1 plume is predicted by the model to discharge into Ashumet Pond.

3.1.2 Ground-Water Quality Samples

Four "fences" of multiple ground-water monitoring wells were installed north of Ashumet Pond, northwest of Johns Pond in the area between the ponds, north of Johns Pond, and east of the northern part of Johns Pond (downgradient of Johns Pond). The fence locations are shown in Figure 2. In addition, several solitary wells were installed in this same general area either up or downgradient of the well fences. Altogether 43 wells were sampled.

The ground-water analytical data indicate the presence of volatile organic compounds and other contaminants in ground water discharging to the ponds; however, concentrations are generally quite low. In several instances, the 1994 Annual Report reasonably attributes certain detected compounds (methylene chloride, acetone, phthalates) to probable contamination during sampling and analysis. Metals and other inorganic compounds are also appropriately compared with expected background levels. Table 3 summarizes the data for Well Fences 2, 4, and 5 and provides a comparison with

Maximum Contaminant Levels set for drinking water by the Federal Safe Drinking Water Act.

Table 3

Chemical Contaminants Observed in Ground Water

Contaminant	Drinking Water MCL (µg/l)	Well Fence 2 (µg/l)	Well Fence 4 (µg/l)	Well Fence 5 (µg/l)
VOLATILE ORGANIC COMPOUNDS FROM CHLORINATED SOLVENTS				
Trichloroethylene	5	4	**16**	**27**
Tetrachloroethylene	5	**6**	3	**6**
cis-1,2-Dichloroethylene	70	2	8	0.6
VOLATILE ORGANIC COMPOUNDS FROM PETROLEUM FUELS				
Benzene	5	-	2	-
Ethylbenzene	700	-	11	-
Xylene	10,000	-	43	-
METALS				
Iron	300*	315	27,200	16,600
Manganese	50*	546	1,450	917
Arsenic	50	-	21.5	18

* Secondary Drinking Water Standard - not health based

The following are compounds detected in ground water that are not explained by sample contamination or natural background levels:

Monitoring Well Fence 2 - North of Johns Pond
TCE was found at 6 µg/l in one well and 1 to 2 µg/l of phenols in two other wells. A very low concentration of the pesticide dieldrin was found in one well during one sampling round.

Monitoring Well Fence 4 - North shore of Ashumet Pond
Trichloroethylene (TCE - a chlorinated solvent) in the range of 10 to 20 µg/l in two wells but not all sampling rounds; ethylene dibromide (EDB - an antiknock compound in fuels, fumigant, and solvent) at less than 1 µg/l in the same two wells and sampling rounds.

Monitoring Well Fence 5 - Northwest shore of Johns Pond in the area between Johns and Ashumet Ponds
The chlorinated solvents TCE and tetrachloroethylene (perchloroethylene or

PCE) were found at concentrations up to 27 and 8 µg/l respectively; EDB was detected at concentrations below 1 µg/l; naphthalene and 2-methylnaphthalene (fuel-derived compounds) were detected at concentrations up to 5 and 11 µg/l respectively. Numerous metals as well as nutrients were found at concentrations above background and were reasonably attributed to release from natural soils due to changes in the water chemistry as fuel compounds were degraded.

Monitoring Well Fence 6 - Northeast shore of Johns Pond

EDB was found at less than 1 µg/l in one well and some metals were elevated above background.

In summary, the ground-water data suggest that contaminated ground water is flowing into the ponds from the MMR, but that the contaminants are at low concentrations. Nonetheless, the concentrations exceed drinking water standards and a preliminary risk assessment in the SERGOU RI report (ABB, 1994) found the ground water in the SERGOU area to be unsafe for consumption.

3.1.3 Surface-Water Quality Samples

Surface-water quality samples were analyzed for both conventional parameters and toxic organic compounds. Conventional parameters were measured to document the stratification cycle of the ponds and to determine their trophic state. The trophic state of a lake is a reflection of the availability of nutrients for the growth of algae. Lakes range from oligotrophic (nutrient poor—literally "poorly fed") to eutrophic (nutrient rich—"well fed"). The introduction of nutrients due to development and other human activity can lead to an excessive growth of algae and diminished water-quality, a process known as cultural eutrophication. Most lakes and reservoirs in temperate climate zones show a distinct seasonal cycle in the structure of temperature with depth. Temperate lakes typically stratify into a warm surface layer overlying a cooler bottom layer during the summer. These layers mix in the fall, a slight restratification may occur in winter, and mixing occurs again in the spring.

The data for Ashumet and Johns Ponds confirm that the ponds follow the typical pattern of seasonal stratification. Both ponds showed near or complete absence of oxygen in deep water during the late summer and early fall, a sign of eutrophication that is common in deep lakes in developed areas. Ashumet Pond was found to be somewhat more enriched with nutrients than Johns Pond, but not significantly more eutrophic. Extensive

phytoplankton abundance data showed diverse taxonomies in both ponds that were basically similar.

An exhaustive statistical analysis of the conventional water-quality data was completed to investigate relationships between water-quality variables within each pond and to explore the differences between the two ponds and reference ponds that were also sampled. We found the statistical analysis to be less than satisfying in that it is an essentially abstract mathematical exercise that is heedless of the nutrient-phytoplankton relationships widely held to control eutrophication. An analysis more closely tied to current understanding of eutrophication (for example, empirical or numerical eutrophication models) should also have been conducted to provide context and insight into the statistical results. Not surprisingly, the statistical analysis found significant correlation between the concentrations of chlorophyll-a and algal biomass and the concentration of phosphorus. Overall, Ashumet and Johns Ponds were found to be similar with greater differences found between different sampling dates within a pond than between the ponds. This observation is consistent with the generally observed differences in phytoplankton biomass between seasons.

Figures 3 and 4 provide a comparison between trophic-state indicator data collected in 1992-1994 during the Ashumet-Johns Pond Study and data collected during earlier studies. In neither pond do the data show clear consistent trends over time. Chlorophyll-a and total phosphorus appear to be higher in Ashumet Pond during recent studies, consistent with a worsening trophic state, but higher Secchi disk measurements indicate an improving trophic state. Thus, no trend is clear. Save for elevated total phosphorus measurements in April 1979 which McVoy (1982) ascribes to laboratory or field error, indicators for Johns Pond are very similar between the recent study and the previous study. The water quality of Johns Pond is overall slightly better than that of Ashumet Pond.

An unfulfilled aspect of the Task Force Recommendations was the charge to develop nutrient mass balances for the ponds and otherwise evaluate the effects of nutrients discharged into the ponds, especially into Ashumet Pond by the STP plume. Also lacking was an analysis that compared and critically evaluated current trophic state indicators

against those measured in the past. Comparison with previous data is hampered by the failure to measure and report total phosphorus during the 1993 program. Total phosphorus is a key indicator of trophic state which was measured in all previous studies of the ponds.

Concentrations of organic compounds indicative of contamination by the MMR ground-water plumes were not found in either pond. Low levels of acetone, methylene chloride, and phthalates were detected but were possibly introduced in the analytical chemistry laboratory. It would be surprising to find volatile organic compounds in the surface water because these compounds, when discharged into the pond with ground water, would be greatly diluted and would readily evaporate through the pond surface.

3.1.4 Storm Water Samples

Storm water samples were collected on a quarterly basis. Although the Sampling and Analysis Plan indicates that automatic samplers will be installed in order to capture the first flush from storm events, such samplers were not in fact installed.

Table 4. Comparison of Observed Storm Water Concentrations with National Urban Runoff Program Data.

Contaminant	Maximum Concentration at Ashumet Pond	Maximum Concentration at Johns Pond	Median Estimated Mean Concentration from NURP
Nitrate (mg/l)	0.77	3.2	0.68
BOD (mg/l)	<1	6	9
COD (mg/l)	2.5	20	65
Total phosphorus (mg/l)	0.18	0.37	0.33
Kjeldahl nitrogen (mg/l)	0.52	0.83	1.5
Copper (µg/l)	9	30	34
Lead (µg/l)	11	150	144
Zinc (µg/l)	21	180	160

BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand

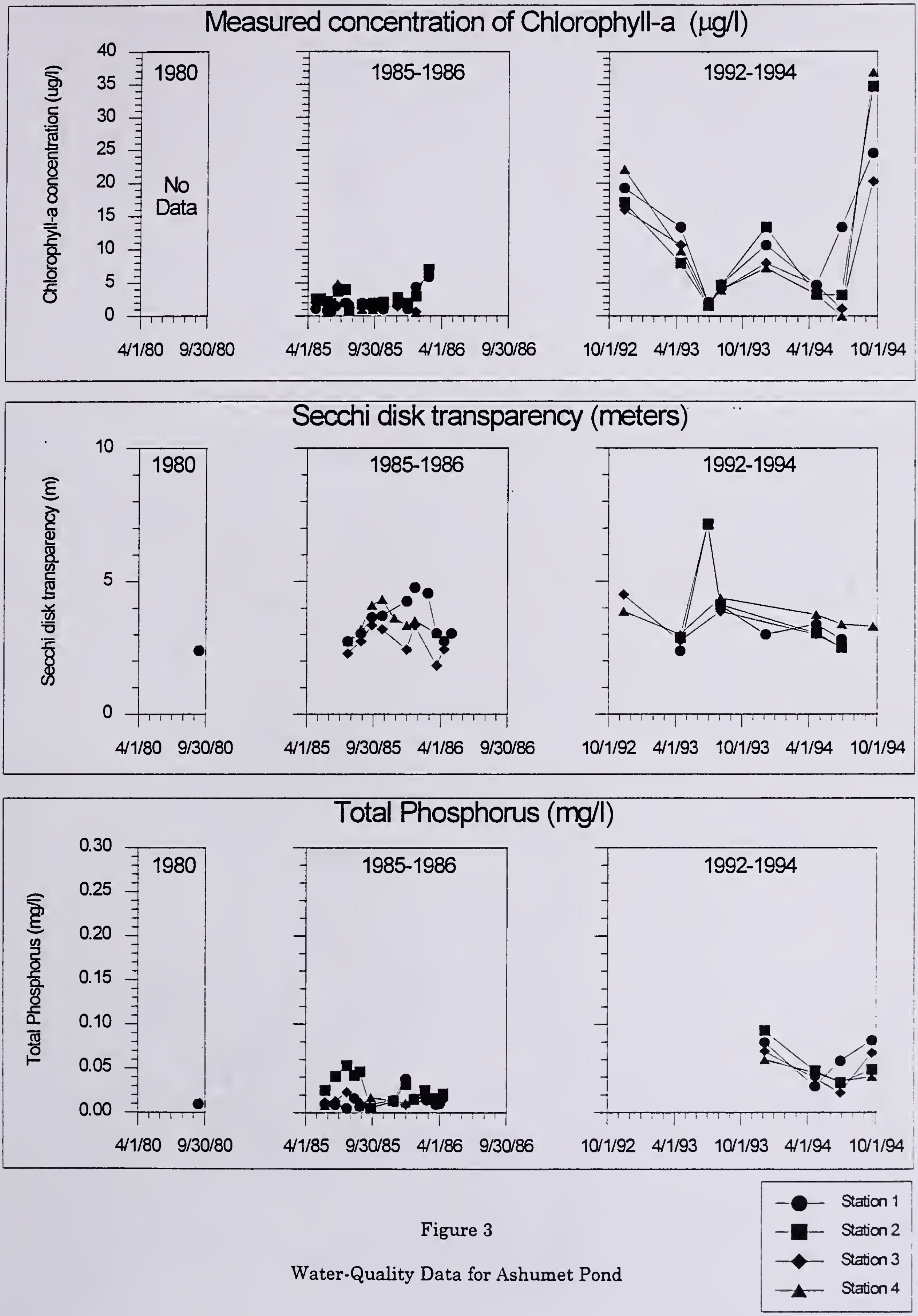

Figure 3

Water-Quality Data for Ashumet Pond

K47-APWQ.GRF 02/08/96

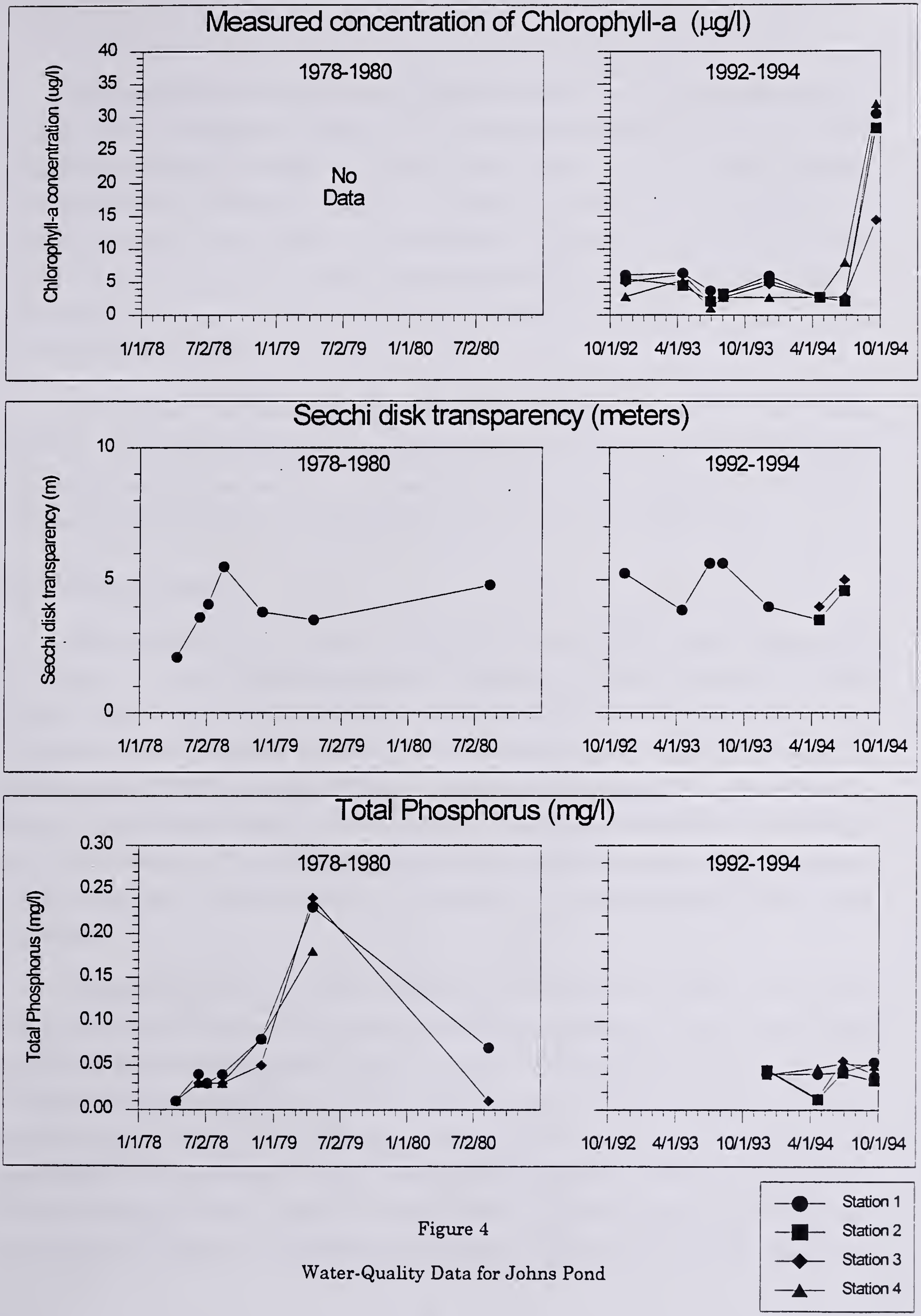

Figure 4

Water-Quality Data for Johns Pond

In general, the level of contaminants found in storm water were unremarkable with respect to the contaminants present and the concentrations observed. The only VOCs detected were methylene chloride and acetone, contaminants that were possibly introduced during sampling or laboratory analysis. A number of metals and conventional water quality parameters were detected at concentrations comparable to or less than typical urban runoff. This is shown in Table 4 which contrasts observed maximum concentrations with median concentrations reported for urban runoff by the National Urban Program (NURP) (U.S. EPA, 1983).

In addition, the pesticides dieldrin, endrin aldehyde, beta-BHC, and alpha-chlordane were detected sporadically at concentrations less than 1 µg/l. An Aroclor of PCB was also detected in one sample at a concentration below 1 µg/l. These detections are also consistent with the character of urban runoff as found during the NURP study.

3.1.5 Sediment Samples

Sediment samples were collected in the third quarter of 1993 at four stations each in Ashumet and Johns Ponds as well as at two catch basins draining to each pond. Volatile organic compounds detected included methyl ethyl ketone, toluene, acetone, carbon disulfide, methylene chloride in Johns Pond and these compounds plus PCE and 1,1,1-trichloroethane (TCA) in Ashumet Pond. Acetone and methylene chloride were found at relatively higher concentrations, possibly reflecting laboratory contamination. A variety of polynuclear aromatic hydrocarbons (PAHs) were also detected at one station in Ashumet Pond. Metals were found at all stations, as would be expected because of their natural occurrence.

Contrary to the Sampling and Analysis Plan, the HAZWRAP reports do not compare the concentrations of metals and other pollutants with guideline concentrations in the MMR Risk Assessment Handbook. Thus, the reports are inconclusive as to the significance of observed sediment contaminants. As discussed below in Section 4, too few sediment samples were taken to satisfy the data requirements to conduct a site-specific risk assessment. We view this as a serious shortcoming inasmuch as sediment is perhaps the only environmental medium other than ground water in which volatile organic compounds are likely to be detected. Contaminants are likely to be introduced into the pore water

from contaminated ground water but pore-water concentrations are less likely to be diminished by dilution and volatilization than are surface-water concentration. For this reason, burrowing and bottom-feeding aquatic species have greater potential to contact contaminants in sediment pore water than do free-swimming species in the water column. Sediment and pore-water contamination thereby has greater potential for creating an ecological hazard.

3.1.6 Benthic Algae Sampling

Benthic algae samples were collected from both natural rocks and emplaced ceramic tiles at six sites in Ashumet Pond and four sites in Johns Pond. Samples were examined to determine taxonomic composition and chlorophyll-a levels. A specific intent of the Task Force for this activity was to assess the differences within Ashumet Pond between the STP plume discharge area and areas elsewhere in the pond. However, the 1994 Annual Report specifically disavows this purpose, saying far more data would be required than were collected (HAZWRAP, 1995b, pg. 7-3). Rather, the report indicates the purpose of the study is to provide baseline data against which future observations may be compared. High cost was indicated as the barrier to a more comprehensive study.

Notwithstanding the qualifications cited above, HAZWRAP reports findings relative to the effects of the STP plume in the 1994 Annual Report. They report chlorophyll-a densities in both ponds are moderate and below the levels at which filamentous algae become problematic. They also report finding no apparent differences between the STP discharge area and other sites in the ponds. The report discusses but draws no conclusions on potential future changes in benthic algae growth as the result of STP plume discharge.

The benthic algae results are curious in not showing higher algal density at the STP plume discharge zone than at other areas in Ashumet Pond and Johns Pond. The 1993 and 1994 Annual Report recognize this anomaly and offer several explanatory hypotheses, but the discussion is ultimately inconclusive for lack of data to distinguish the cause or causes of the anomaly.

3.1.7 Bioaccumulation (Fish) Sampling

Fish were sampled three times during the Ashumet and Johns Pond Study and were subject to an internal and external inspection for general health (determination of Health Assessment Index - HAI), blood analysis, a microscopic inspection of tissue for signs of disease (histopathology examination), and chemical analysis of tissue.

Chemical analysis of fish revealed several compounds present at levels exceeding U.S. EPA risk-based concentrations. The EPA concentrations are based on an assumed year-round consumption of 54 grams per day (0.8 pounds per week) and represent the EPA's recommendation of the level at which human health is endangered with a risk of 1 in 1 million for cancer. Analyses were done on both whole-body samples from single fish and composite samples of filets from multiple fish. Presuming the latter best represents what the public would eat, the following summarizes instances where maximum concentrations were found to exceed the EPA criteria:

Ashumet Pond	Brown bullhead	DDE, DDD
	Largemouth bass	DDD, Mercury
	Smallmouth bass	DDD
	Yellow perch	DDE
	Trout	none
Johns Pond	Brown bullhead	Heptachlor
	Largemouth bass	Mercury
	Smallmouth bass	Dieldrin, Mercury
	Trout	none

Heptachlor and dieldrin are pesticides while DDD and DDE are breakdown products from the pesticide DDT. These pesticide-related compounds and mercury are often seen in fish in the northeast and their presence in fish in Ashumet and Johns Ponds does not necessarily indicate sources other than atmospheric deposition and the general distribution of these chemicals in the environment. Because of their ubiquitous nature, no conclusion can be drawn as to the link between these chemicals and the MMR.

Fish health assessments found that the overall health of the fish in Ashumet and Johns Ponds was poorer than in other Cape Cod ponds and lakes sampled to provide a comparison. The most consistent indicator of poor health is a high prevalence of oral and

body surface papillomas on brown bullhead catfish in the ponds. Evidence of liver damage was also found in several fish species. The report is inconclusive as to the cause of the catfish papillomas, although it cites literature studies linking increased incidence of papillomas to environmental pollution. The report states that "none of these observations can be conclusively linked to either environmental contamination in general or MMR in specific." This is supported by an independent study by the Woods Hole Oceanographic Institution (Moore *et al.*, 1995) that attributes catfish papillomas to a virus rather than chemical exposure based on a limited laboratory experiment. In light of the considerable public knowledge of and concern over the catfish papillomas, we recommend further studies to determine more definitely their cause.

The increased incidence of papillomas alone is not necessarily an indication of ecological risk. It suggests evidence of exposure to contamination, but is not compelling evidence of an effect jeopardizing the catfish as a population. The catfish in Johns and Ashumet Ponds may be reproducing as successfully as are the catfish in the reference ponds, regardless of this pathological condition. Also, the presence of these papillomas does not necessarily indicate a potential risk to humans. The finding does point out the need for a systematic risk assessment as discussed in Section 4 below. The observation of papillomas would be useful in the development of an ecological risk assessment along with other lines of evidence. If a risk assessment incorporating all lines of evidence, including the papillomas, indicated that there is potential risk to fish populations, then it would be useful to follow these initial observations with an assessment of the population structure and breeding success of exposed fish populations.

3.1.8 Bioaccumulation (Mussel) Sampling

Mussels were collected and analyzed in 1993 only. The 1993 Annual Report recommends, without explanation, that mussel sampling not be conducted in 1994.

Chemical analysis of mussel tissues found mercury, the pesticide δ-BHC, several phenolic compounds, one PAH compound, PCE, and toluene in one or more samples from Ashumet or Johns Ponds. None were at levels considered a threat to human health. Methylene chloride and acetone were also found, but probably originate from contamination in the laboratory.

The 1994 Annual Report explains that sample preparation and analysis is such that detection of VOCs in tissue is essentially impossible and that all VOC detections are therefore suspect. Unfortunately, VOCs are the toxic organic contaminants most prevalent in the MMR plumes. This finding in the final annual report of the study is troubling insofar as it concerns the fundamentals of the methods used and does not arise from the particular results of this study. As such, the limitations of the method could and should have been identified when the Sampling and Analysis Plan was being formulated and more effective alternative methods specified in the plan. We question the finding now, after two years of mussel and fish tissue analysis, that the analysis approach is fundamentally flawed for the constituents of greatest concern and likelihood. While we have seen VOCs detected in fish tissue at another site, in general VOCs are not likely to be present due to the reasons cited above and the fact that they generally do not bioaccumulate in fish.

3.1.9 Study Conclusions

The final conclusion of the 1994 Annual Report is:

> The data indicate no direct link between Base activities and contaminant concentration levels in either Ashumet or Johns Ponds. The potential exists, however, for MMR-related contaminated groundwater plumes to adversely affect the water quality of both ponds in the future.

We believe this conclusion is stated with more certainty than is justified by the data collected during the Ashumet and Johns Ponds Study. The study makes clear that ground water contaminated by base activities is discharging to both ponds. The study omits the STP plume from its ground-water analysis, but this plume is irrefutably discharging to Ashumet Pond, introducing nutrients and other constituents in the process. The study also shows that fish populations are in poor health in the ponds, but fails to determine the cause of that poor health.

Study results indicate that volatile organic compounds from the southeast regional plumes seem to be reaching the ponds in low quantities. However, surface-water and biological samples are poor indicators of such contamination for reasons discussed previously in this section. Sediment samples are more likely to show the presence of these compounds, but were taken in insufficient quantity to be conclusive. The most promising technique for determining the flux of contaminants into the ponds is the collection of

seepage samples from the pond beds. This activity was recommended by the Johns Pond Ashumet Pond Task Force but never conducted by the National Guard Bureau. We believe it is important to follow up on this task to understand as completely as possible the degree to which contaminants are present in bottom sediments and associated pore water. Additional studies of benthic macroinvertebrates for evidence of contamination effects is also recommended. Histopathological studies may be more fruitful in this respect than additional chemical analyses.

As stated above, the plume of sewage-contaminated ground water from the MMR sewage treatment plant is clearly discharging to the Fisherman's Cove section of Ashumet Pond. A key objective of the Task Force was to collect the data necessary to determine this nutrient load to the pond and evaluate its effects. Benthic algae data were apparently inconclusive in this respect, although the 1994 Annual Report indicates that the study design was inadequate to reach any finding other than an inconclusive one. The 1994 Annual Report shows that the lack of a clear effect from the STP plume was an unexpected finding for which there is no compelling explanation. This is a highly unsatisfactory conclusion and more study is warranted.

The HAZWRAP analyses also fail to quantify the nutrient loads to the ponds and evaluate their expected effects in light of the collected field data. A startling omission is the failure to contrast the 1993-1994 data with previously collected data. Overall, the studies fail to reach meaningful conclusions about the effects of ground-water intrusion on the trophic state of the ponds although there appears to be adequate data to do so.

In two instances, the 1994 Annual Report indicates that the collected data are inadequate for purposes of satisfying the recommendations of the Johns Pond Ashumet Pond Task Force. The report indicates that the benthic algae study is insufficient for determining if the STP plume is affecting algal growth and that chemical analysis of fish and invertebrate tissue is unable to detect volatile organic chemicals. It is unfortunate that these limitations are indicated now, at the conclusion of the study, rather than at its commencement. These disavowals should have appeared in the Sampling and Analysis Plan prior to the study in order to make the Task Force and concerned citizens aware of these limitations so that they could have had appropriate input at that time.

3.2 SATISFACTION OF TASK FORCE RECOMMENDATIONS AND WORK PLAN

Tables 5 and 6 provide a cross comparison between the tasks specified in the Task Force recommendations and the Sampling and Analysis Plan against those actually completed during the Ashumet and Johns Pond study.

Significant deviations between the Task Force Recommendations and the work actually completed include the failure to collect seepage samples, the failure to install automatic sampling equipment and thereby adequately characterize storm water, and the unexplained cessation of invertebrate bioaccumulation studies after one year. As discussed above, the study failed to meet the spirit of the Task Force Recommendations insofar as data analysis was concerned and many of the questions raised by the Task Force were left unanswered.

There were fewer deviations from the Sampling and Analysis Plan and most of those deviations originated legitimately from field conditions. For example, grain size distributions were not analyzed for sediment samples owing to poor capture. Deviations without a clear explanation were the sampling of fewer catch basins for sediment than specified in the plan, the failure to install automatic sampling equipment for storm water, and the failure to measure irradiance in association with the benthic algae study. On the other hand, more fish samples were taken than called for in the plan.

Table 5. Comparison Between Johns Pond Ashumet Pond Task Force Recommendations and Completed Study.

Task Force Recommendations	Recommended Sampling	Data Collected in Years 1 & 2	Deviations from Recommendations
HYDROGEOLOGIC INVESTIGATION			
Install monitoring wells up and downgradient of Ashumet and Johns Ponds	One time	45 wells installed in 1992	
Profile subsurface flow through pond bottom	One time		Not done
Define vertical flow	One time		Reported in RIs
Meter seepage through pond bottoms	One time		Not done
GROUND-WATER QUALITY SAMPLING			
Sample where plumes enter ponds	Quarterly for two years	6/93, 11/93, 8/94,12/94	June 1993 data not reported in quarterly or annual report
Sample private wells			Not done
Determine if VOCs in FTA-1 plume discharge to Ashumet Pond			Reported in SERGOU RI
SURFACE-WATER QUALITY SAMPLING			
Before, during, after stratification	Seasonal for two years	11/92, 4/93, 6/93, 8/93, 12/93, 4/94, 6/94, 9/94	
SEDIMENT SAMPLING			
Deep hole areas of ponds	One time	8/93	
Near-shore areas (deltas)	One time	8/93	
In drainage swales	One time	8/93	
STORM-WATER SAMPLING			
Review current sampling approach			Review led to recommendation to install automatic samplers, but never done
Monitoring of SD-2 and SD-3	Automatic samplers	10/92, 1/93, 4/93, 9/93, 12/93	Samples collected manually, missing "first flush"
BENTHIC ALGAE INVESTIGATION			
Taxonomic composition and density	Quarterly for two years	5/93, 8/93, 9/93, 5/94, 8/94, 9/94	1994 samples in Ashumet Pond only
Correlation in taxonomic composition and density with phosphorus in Ashumet Pond			Qualitative analysis only
Correlation in taxonomic composition and density with plume constituents			Not possible due to infrequent chemical detection
FISH BIOACCUMULATION INVESTIGATION			
Histopathic examination of fish tissue	Once per year for two years	10/92, 5/94, 9/94	
Analytical chemical testing of tissue	Once per year for two years	10/92, 5/94, 9/94	
Bioassay of tissue (Cytochrome P450)	Once per year for two years	10/92, 5/94, 9/94	Cytochrome P450 not used
MOLLUSC BIOACCUMULATION INVESTIGATION			
Histopathic examination of tissue	Once per year for two years	8/93	Done for one year only
Chemical testing of tissue	Once per year for two years	8/93	Done for one year only
BIOTA AND RARE AND ENDANGERED SPECIES INVESTIGATIONS			
Species surveys in ponds and vicinity	Once		Not done
Survey of rare and endangered species	Once		Not done
Literature search on effect of plume contaminants on rare and endangered species	Once		Reported in RIs

Table 6. Comparison Between Sampling and Analysis Plan and Completed Study.

Parameter or Activity	Planned Sampling	Data Collected in Years 1 & 2	Deviations from Plan
GROUND-WATER QUALITY SAMPLING			
VOCs, SVOCs, Pesticides, Metals	Every 6 months	6/93, 11/93, 8/94, 12/94	June 1993 data not reported in quarterly or annual report
Nutrients	Every 6 months	6/93, 11/93, 8/94, 12/94	
SURFACE-WATER QUALITY SAMPLING			
General water-quality parameters	Seasonal	11/92, 4/93, 6/93, 8/93, 12/93, 4/94, 6/94, 9/94	
CLP parameters	Summer and winter	4/93, 8/93, 4/94, 9/94	
Cranberry bog and Ashumet near-shore area	Under RI		
SEDIMENT SAMPLING			
Pond sediments	3rd Quarter 93	8/93	
Catch basins, road drains, stream deltas	3rd Quarter 93	8/93	4 catch basins only
Grain size	3rd Quarter 93	Not done due to poor recovery	Under SERGOU RI
CLP parameters	3rd Quarter 93	8/93	
Nutrients	3rd Quarter 93	8/93	
STORM-WATER SAMPLING			
Storm water outfalls (SD-1, SD-2, SD-3, SD-4)	Automatic samplers	10/92, 1/93, 4/93, 9/93, 12/93	Samples collected manually, missing "first flush"
Correlation between storm intensity and discharge to ponds	Event based sampling		Not done
BENTHIC ALGAE INVESTIGATION			
Taxonomic identification and enumeration	Over 2 years	5/93, 8/93, 9/93	
Field parameters including irradiance	Over 2 years		Irradiance not measured
FISH BIOACCUMULATION INVESTIGATION			
Macroscopic morphology	1st Quarter 93	10/92, 5/94, 9/94	
Histopathology	1st Quarter 93	10/92, 5/94, 9/94	
CLP parameters	1st Quarter 93	10/92, 5/94, 9/94	
Lipids	1st Quarter 93	10/92, 5/94, 9/94	
Blood chemistry	1st Quarter 93	10/92, 5/94, 9/94	
MUSSEL BIOACCUMULATION INVESTIGATION			
CLP parameters	3rd Quarter 93	8/93	
Lipids	3rd Quarter 93	8/93	

4. REVIEW OF STUDY ADEQUACY FOR RISK ASSESSMENT

4.1 INTRODUCTION

The purpose of this section is to review the adequacy of the information collected by the National Guard Bureau (NGB) to support future ecological and human health risk assessments of Ashumet and Johns Ponds.

This section relied upon a review of various documents prepared for the National Guard Bureau, including:

- Ashumet and Johns Ponds 1993 quarterly and annual reports, Final. 1994;
- Ashumet and Johns Ponds 1994 quarterly and annual reports, Draft. 1995;
- Ashumet and Johns Ponds Sampling and Analysis Plan, Draft. September, 1992;
- Ashumet and Johns Ponds Sampling and Analysis Plan, Final. August, 1993;
- Johns Pond Groundwater Underflow Study. January 1991;
- Mashpee Groundwater Study. August 1990;
- Ashumet Pond. A Diagnostic/Feasibility Study. January 1991;
- 1978-1980 Johns Pond Diagnostic/Feasibility Study. March 1982;
- Plume Response Plan. June 1994.

These reports do not provide information in a risk assessment framework although the information provided in them would be useful to support risk assessments of the ponds. We therefore reviewed and organized the data from these studies using current EPA ecological and human health risk assessment paradigms and EPA guidance documents. This approach allows for a complete, systematic review of the available data to support risk assessments consistent with current regulatory guidance.

The general approach in this review is to:

- describe the components of ecological and human health risk assessment as currently provided in EPA guidance;

- assess the sufficiency of the existing data for Johns and Ashumet Ponds to meet the requirements of each of these components and identify potential data gaps;
- make recommendations regarding the type of data which may help fill identified data gaps.

The review is in two sections: ecological risk assessment, and human health risk assessment. Section 4.2 reviews the adequacy of the NGB studies to support an ecological risk assessment using the *Framework for Ecological Risk Assessment* (U.S. EPA, 1992). Section 4.3 provides a similar review for human health risk assessment using the "four step" paradigm presented in *Risk Assessment Guidance for Superfund (RAGS)* (U.S. EPA OERR, 1989b).

4.2 ECOLOGICAL FRAMEWORK

We use EPA's *Framework for Ecological Risk Assessment* (U.S. EPA, 1992) to review the adequacy of the Ashumet and Johns Ponds studies for supporting an ecological risk assessment and to determine if additional data are necessary. The framework consists of three major components: *Problem Formulation*, *Analysis*, and *Risk Characterization*. These components include many different elements. *Problem Formulation* includes a preliminary characterization of exposure and effects and presents the objectives of the assessment. The *Analysis* component of the framework consists of two activities, *Characterization of Exposure* and *Characterization of Ecological Effects*. *Risk Characterization* uses the results of the *Analysis* to evaluate the likelihood of adverse ecological effects associated with exposure to contaminants or other stressors.

4.2.1 Problem Formulation

Problem Formulation is the first component of ecological risk assessment and establishes the goals, breadth and focus of the assessment. Entry into the *Problem Formulation* and ecological risk assessment process may be triggered by observed or predicted ecological effects or the introduction or identification of a potential stressor. Problem Formulation then proceeds with an initial characterization of exposure and ecological effects and the ecosystem potentially at risk. Next, assessment and

measurement endpoints are identified. Finally, a conceptual model is developed which describes how stressor(s) interact within the environment and ecological components.

IDENTIFICATION OF CHEMICALS OF CONCERN

Definition: The number of chemicals detected at a site are often too numerous to fully quantify all possible risks. Therefore, a subset of these chemicals, referred to as "chemicals of concern," are selected to provide focus for the risk assessment. This subset of chemicals are chosen to represent the chemicals most likely to contribute to the overall ecological risk. Chemicals of concern are typically selected based on criteria such as:

- Frequency of detection;
- Magnitude of concentration;
- Toxicity of the chemical;
- Bioaccumulation potential of the chemical;
- Persistence of the chemical;
- Environmental persistence of the chemical; and,
- Chemical concentrations relative to background concentrations (for metals).

Once chemicals of concern have been identified, contaminant distribution is also typically characterized. This information helps define the ecosystems potentially at risk as well as the ecological effects that may result.

Sufficiency of Existing Data: The National Guard Bureau (NGB) studies provide insufficient information to identify chemicals of concern. Chemical concentrations were measured in surface water and sediment at four Ashumet Pond stations and five Johns Pond stations. This is an insufficient quantity of samples from which to select chemicals of concern if frequency of detection is a criterion. These samples also do not provide sufficient spatial resolution to characterize the extent of chemical contamination in the ponds. For example, one of the Johns Pond sediment samples, JPSD-3, contained elevated levels of metals compared to the other four samples. However, because of the limited number of sediment samples, it is difficult to delineate the area or areas which may contain elevated levels of metals. Additionally, the NGB studies do not completely characterize the toxicity, bioaccumulation, and persistence of the site chemicals.

Recommendations:

1. Develop a supplementary sampling and analysis work plan to identify additional sediment and surface-water stations, based on potential ecological exposures. Samples from additional locations are necessary to better characterize the chemicals present at Ashumet and Johns Ponds. We feel that additional sediment data are especially important to better characterize the distribution of volatile organic compounds which may seep from the ground-water plumes. The sediment and pore water are likely to best represent exposure media that contain relatively undiluted concentrations of volatile organic compounds. Sediment and pore water are important exposure media for bottom-dwelling fish and benthic invertebrates. The work plan should identify sample locations which would most improve the spatial resolution of the current data set. Additional samples will also increase the sample pool from which chemicals of concern are selected.

2. Research the toxicity, bioaccumulation, and persistence of the detected chemicals to determine their potential for affecting ecological components. This information can be obtained from a variety of sources. Information on chemical toxicity can be obtained from databases such as U.S. EPA's Integrated Risk Information System (IRIS) and the chemical profile series published by the Agency for Toxic Substances and Disease Registry (ATSDR). Bioaccumulation and persistence of chemicals can be obtained from such sources as the Hazardous Substances Data Bank (HSDB) and U.S. EPA's Aquatic Information Retrieval (AQUIRE) database.

CHARACTERIZATION OF RECEPTORS AND HABITAT

Definition: The plants, animals and habitat of the site are characterized in ecological risk assessment to provide detailed information on the types of biota which may be exposed to chemicals of concern. This characterization may include descriptions of the nature and composition of plant and animal communities in the immediate vicinity; and, descriptions wildlife habitat and key food organisms. From this list, endangered or threatened species or species which may be sensitive to the effects of site chemicals are identified.

Sufficiency of Existing Data: The NGB studies only partially characterize the Ashumet/Johns Ponds ecosystem. There is considerable characterization of the phytoplankton, and some information on fish species. This information includes observations of gross pathologies associated with the fish.

[illegible]

Recommendations:

1. Conduct a literature review to provide background information on the plant and animal species expected to occur at the ponds and in proximate areas; the use of the general area by migrating or over wintering species; and the general distribution and abundance of species in the area. The review may include an examination of data bases from agencies such as U.S. Fish and Wildlife Service; U.S. EPA Region I; and, Massachusetts Department of Environmental Protection.

2. Conduct a biological/habitat survey of the ponds to identify the nature and composition of aquatic and terrestrial animal and plant communities in the vicinity of the ponds. The survey should identify:

   - major flora in the ponds and adjacent areas;
   - fish species in the ponds; and,
   - amphibian, mammal and bird species;
   - habitat types associated with the pond such as bordering wetland, vegetated beds, open or vegetated banks, et cetera.

3. Based on the results of these surveys, identify sensitive, threatened and endangered species. A list of Massachusetts endangered, threatened, and rare species is available from Massachusetts Division of Fisheries and Wildlife. A list of federal endangered and threatened species is available from the U.S. Fish and Wildlife Service.

4. Based on the results of the surveys, characterize the food-web dynamics of the ponds. This characterization will provide focus for the development of the site conceptual model.

5. Conduct a benthic invertebrate survey to characterize the individual species and quantities present in each pond. Results of the survey should provide a variety of benthic community parameters such as abundance, species diversity, and differences between sampling stations. Benthic sampling stations should correspond with sediment sampling locations to try to relate chemical concentrations to benthic invertebrate community characteristics.

PRELIMINARY CHARACTERIZATION OF ECOLOGICAL EFFECTS

Definition: Ecological effects are initially characterized in the assessment to provide focus on the specific chemicals and ecological components which need to be evaluated. Ecological effects data may consist of field observations, field tests, laboratory tests, or chemical structure-activity relationships. Preliminary information may be obtained from literature review.

Sufficiency of Existing Data: The NGB studies do not provide toxicological data for fish or wildlife.

Recommendations:

1. Research acute and chronic toxicity studies for both fish and wildlife for chemicals detected. This information should help provide perspective on the critical endpoints associated for each chemical. For example, toxicological information on pesticides may focus on reproductive effects and eggshell thinning, while toxicity studies for volatile organic compounds may focus on systemic narcotic effects. This information should be used to assist in identifying chemicals of concern (see previous section) and defining and selecting assessment endpoints (see following section).

ENDPOINT SELECTION

Definition: Endpoints are characteristics of an ecological component that may be affected by chemicals. There are two types of endpoints in ecological risk assessments, assessment endpoints and measurement endpoints. Assessment endpoints, the ultimate focus of the risk assessment, are explicit expressions of the actual environmental value that is to be protected. The assessment endpoint should not only be ecologically relevant, but also reflect policy goals and societal values. Measurement endpoints are measurable responses to chemicals that are related to the characteristics chosen as the assessment endpoints. If the assessment endpoint can be measured, then the assessment and measurement endpoints are the same. In most cases, however, the assessment endpoint cannot be directly measured, so one or more measurement endpoints are selected that can be related to the assessment endpoint. The selection of assessment endpoints is critical in determining the purpose and focus of the risk assessment.

Sufficiency of Existing Data: The NGB studies do not identify assessment endpoints for Ashumet or Johns Ponds. Without endpoints, we cannot completely evaluate the adequacy of the NGB studies, since the assessment endpoints determine the type and quantity of data required. We have therefore evaluated the NGB data assuming the assessment and measurement endpoints identified below.

Recommendations:

1. Identify assessment and measurement endpoints. Examples of possible assessment and measurement endpoints for Ashumet and Johns Ponds include:

Assessment Endpoint	Suggested Measurement Endpoints
Protection of pond trophic status	increased phytoplankton growth decreased levels of dissolved oxygen
Protection and preservation of fishery	bioaccumulation of chemicals in fish fish pathology preservation of food base low levels of dissolved oxygen in water column
Protection of wildlife	bioaccumulation of chemicals in wildlife wildlife pathology preservation of food base
Protection of recreation	preservation of swimming, boating, fishing

The adequacy of these endpoints should be evaluated by Ashumet-Johns Pond TAG Coalition Committee and other interested parties to determine if they reflect interests of the local and regional community.

In general, we felt that the existing studies provide a more than adequate data base to evaluate the endpoint, "protection of pond trophic status." We therefore have not recommended any further studies to address this assessment endpoint.

SITE CONCEPTUAL MODEL

Definition: The site conceptual model represents a series of working hypotheses regarding how chemicals might affect ecological components. The information developed as part of the previous sections is used to construct a preliminary analysis of the ecosystem, the chemicals of concern, and the ecological affects to determine possible exposure scenarios. Each scenario is defined in terms of the chemical(s), the type of receptor, and how the chemical(s) interact within the environment. The site conceptual model includes the identification of exposure pathways, which consist of four elements:

1. A source and mechanism of chemical release into the environment.
2. An environmental transport medium for the released chemical and/or a mechanism of contaminant transfer from one medium to another.
3. A point of potential contact for plants or animals with the contaminated media.

4. An exposure route at the point of exposure.

Sufficiency of Existing Data: The NGB studies do not provide a site conceptual model for Ashumet or Johns Ponds. Information on the toxicity and fate and transport of the chemicals of concern, and the types of wildlife have not been researched. In addition, assessment endpoints have not been selected.

Recommendations:

1. Develop a site conceptual model after the information identified in previous sections has been obtained or collected. Figure 5 presents an example of a site conceptual model for Ashumet and Johns Ponds based on the assessment endpoints suggested in the previous section of this report. The conceptual model identifies the sources of contaminants (stressors) as: Massachusetts Military Reservation (MMR) spills, leaks and discharges; underground septic tanks; and, lawn fertilizer. MMR sources have resulted in contaminant plumes which may have or might seep into Ashumet and Johns Ponds. Affected media in the ponds may include the sediment, pore water, and the water column. A variety of receptors may be exposed to these contaminated media. For example, forage fish may be exposed to contaminated surface water via respiration and dermal contact, and to contaminated plankton via ingestion. The examples provided in Figure 5 are not intended to be exhaustive, however. A biological survey of the area is necessary to identify other possible sensitive species (e.g., small mammals or raccoons) which may be at risk.

4.2.2 Analysis

CHARACTERIZATION OF EXPOSURE

Definition: The exposure assessment identifies pathways and routes by which site contaminants may reach receptors and contaminant concentrations at the points of exposure. This information is then integrated with known or predicted movement or foraging so that an estimate of exposure for each pathway and contaminant can be estimated. As presented in Figure 5, there may be several pathways of exposure for a given receptor. Some of the potential exposure media include air, ground water, pore water, surface water, sediment, soil, and food. Based on an initial list of exposure pathways, a screening assessment should be conducted to determine which pathways are most significant. Factors which should be considered in this screening process include the frequency and duration of the exposure and the relative contribution of the exposure to the risk.

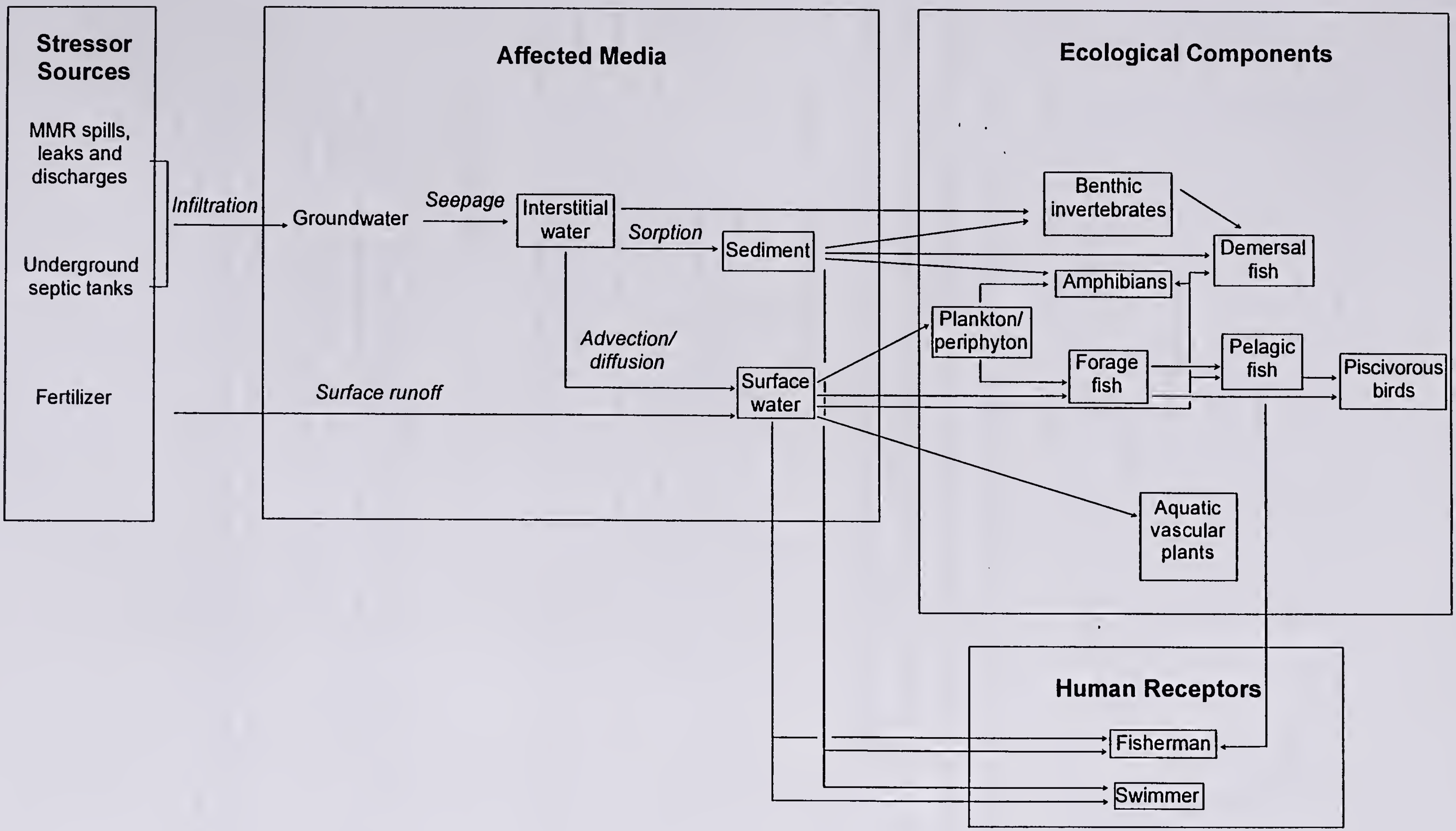

Figure 3

Example of Site Conceptual Model for Ashumet and Johns Ponds

As part of the characterization of exposure, the risk assessment needs to estimate the exposure point concentrations for each receptor and pathway selected. For example, for the case of a fish exposed to chemicals in water and food, the risk assessment would estimate the exposure point concentrations of chemicals in both water and food. The concentrations are typically expressed in mass per unit volume (e.g., mg/l) or mass per unit weight (e.g., mg/kg). In general, exposure point concentrations are estimated from measured chemical concentrations. Data used in the assessment should be representative of the receptors exposure (e.g., foraging behavior).

Once exposure point concentrations have been estimated, exposure doses may be developed for wildlife receptors. Units of exposure doses are typically mass of chemical per mass of body weight per unit time (e.g., mg/kg/day). Exposure doses are typically compared to reference doses to determine the potential for adverse effects.

Sufficiency of Existing Data:

The current data do not provide a strong basis for performing an ecological exposure assessment. The number of sediment and surface water stations are limited to four for Ashumet Pond and five for Johns Pond. Because these stations are potentially farther apart than the foraging range of the fish that may be present in the ponds, the data do not provide a sufficient characterization of exposure. In addition, the data are not sufficient to fully characterize exposure to benthic invertebrates which are relatively immobile.

Recommendations:

1. As stated in Section 2.1.1, develop a supplementary sampling and analysis work plan to obtain additional sediment and surface water samples. These samples are necessary to better characterize potential exposure. Additional stations would provide an improved estimate of exposure for aquatic receptors, including fish and benthic invertebrates.

2. The fish chemical body burdens reported in the NGB reports appear to provide sufficient data to estimate exposure point concentrations for animals which may consume fish. Additional fish tissue analysis is therefore not recommended.

CHARACTERIZATION OF ECOLOGICAL EFFECTS

Definition: The risk assessment provides information on the toxicity of the chemicals of concern to determine the potential severity and types of effects which may occur. The toxicity of each chemical of concern should be provided for both acute and chronic exposures, and for all available endpoints, such as systemic carcinogenic, mutagenic, reproductive and developmental effects. Reference doses or concentrations, levels at which adverse effects to a receptor are anticipated, should be estimated based on toxicological literature or studies. Reference concentrations for aquatic receptors are often expressed as mass per unit volume (e.g., mg/l), while reference doses for wildlife are often expressed as mass chemical per mass body weight per unit time (e.g., mg/kg/day).

Sufficiency of Existing Data: The NGB studies do not provide a sufficient discussion of toxicological effects of chemicals of concern. In addition, the studies do not identify endpoints (i.e., reference doses and/or concentrations) to assess ecological effects.

Recommendations:

1. Research the toxicological effects of the chemicals of concern. The results of this research should be chemical profiles which discuss the types of ecological effects which may occur and at what level or dose these effects are anticipated to occur.

2. Select ecological endpoints for each receptor. The endpoints should reflect the stated goals of the assessment. A table of reference doses and associated effects should be developed for both fish and wildlife receptors.

4.3 HUMAN HEALTH RISK ASSESSMENT FRAMEWORK

Human health risk assessments are conducted based on U.S. EPA guidance (U.S. EPA, 1989a) and contain the following components:

- Data Evaluation and Identification of Chemicals of Concern;
- Exposure Assessment;
- Dose-Response Assessment;
- Risk Characterization; and,
- Uncertainty Evaluation.

4.3.1 Data Evaluation and Identification of Chemicals of Concern

Definition: Chemicals of Concern are those chemicals likely to significantly contribute to human health risks at a site. The initial list of chemicals of concern contains those chemicals found in any media above the detection level. A subset of chemicals is chosen that represents the chemicals of concern at a site. Chemicals of concern are typically selected based on the following criteria:

- Frequency of detection (statistical frequency);
- Magnitude of concentration;
- Known or suspected source areas;
- Historical use of the site;
- Toxicity of the chemical;
- Bioaccumulation potential of the chemical;
- Fate and transport mechanisms likely to impact potential exposures;
- Environmental persistence of the chemical; and,
- Chemical concentrations relative to background concentrations (for metals).

Contaminant distributions in each of the media at the site are characterized for the chemicals of concern. Fate and transport mechanisms affecting the potential migration of the chemicals are identified, and where possible, quantified to evaluate current and future exposure scenarios. Data summary tables present the range of detected concentrations, the frequency of detection, and average and upper bound concentrations of contaminants.

Sufficiency of Existing Data: The NGB studies provide data for surface water and sediment at four Ashumet Pond stations and five Johns Pond stations, as well as for several species of fish. The Target Analyte List (TAL) includes volatile organic compounds, semi-volatile organic compounds, pesticides, and polychlorinated biphenyls. The ponds were sampled eight times over a two-year period. However, the number of sampling locations does not provide a statistically significant number of samples. Consequently, any contaminant detected even once in any media would likely be retained in all analyses. Frequency of detection and magnitude of concentration are difficult to assess if only a few data points are available.

Recommendations:

1. A larger data set would provide more information on contaminant distribution, magnitude of contaminant concentration, and frequency of detection at the site. Although the chemicals of concern can be selected based on existing data, it would be advisable to obtain additional samples, particularly from the sediments close to the shoreline of the ponds where human exposures may occur.

4.3.2 Exposure Assessment

Definition: The exposure assessment identifies the human receptors who may come in contact with the contaminants at or from the site. Current and anticipated future land uses are identified at and near the site. For example, likely receptors at Johns and Ashumet Ponds include persons who may swim or fish at these ponds. Swimmers may potentially be exposed to surface water and sediments, while people who fish may ingest potentially contaminated fish tissue. Exposure point concentrations are calculated, based on available monitoring data for the site. If contaminant migration or other fate mechanisms are determined to be issues for either current or future exposure scenarios, fate and transport modeling is conducted to quantify and estimate contaminant concentrations.

Sufficiency of Existing Data: Little discussion is provided in the NGB documents relative to potential human receptors at the site. There is currently not enough information contained in these reports to characterize potential exposures at the site. Although the chemical data are adequate to conduct a human health risk assessment, there is significant uncertainty in any quantitative estimate based on such a limited number of samples. For example, receptors may potentially be exposed to sediments while swimming in the ponds. The calculated exposure point concentrations rely on only three or four samples in characterizing exposures. Characterization of exposure can be accomplished through the use of a single maximum measured contaminant concentration in a particular environmental medium; however, the uncertainty in such an estimate is considerable.

The NGB studies provide some information on the bioaccumulation potential for several of the potential chemicals of concern. These data need to be reviewed to evaluate trends and to predict future expected concentrations.

Recommendations:

1. Develop information to characterize potential human exposures through a review of local maps and area zoning information, a site visit, and interviews with local residents who may use the site recreationally.

2. The fate and transport mechanisms, including bioaccumulation into edible fish, which bring the contaminants of concern to human receptors should be evaluated.

4.3.3 Dose-Response Assessment

Definition: The dose-response assessment describes the adverse effects associated with specific doses and routes of exposure for the chemicals of concern at a site. The dose-response assessment evaluates the potential carcinogenic and non carcinogenic effects of chemicals and provides quantitative toxicity estimates for use in the risk characterization. Toxicity profiles for each of the chemicals of concern are provided, and all toxicity information is reviewed by a toxicologist. In the event a U.S. EPA-derived toxicity factor is not available, a toxicologist reviews the available information and, in many cases, derives a toxicity estimate. Absorption efficiencies for the chemicals of concern are reviewed and adjusted accordingly to account for route and duration of exposure.

Sufficiency of Existing Data: There are no toxicological data provided in the NGB studies. Toxicity profiles for the potential chemicals of concern at the site are not available in these documents.

Recommendations:

1. U.S. EPA developed and approved toxicity factors are available from the U.S. EPA Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (FY-1994 and updates). These sources need to be consulted to determine which of the potential chemicals of concern at the site have U.S. EPA-approved toxicity factors. Further information is available through the National Library of Medicine's MEDLARS database, TOXNET, and Dialog Information Services. The toxicity of each of the potential chemicals of concern should be reviewed, and toxicity profiles written.

4.4 SUMMARY

The available data set is amenable to a screening-level ecological assessment of the ponds. However, a screening assessment requires many conservative assumptions which will result in a high level of uncertainty. Such uncertainty will limit the use of the assessment as a risk management tool.

The major point of this review is that the approach to assessing risk to the ponds should follow EPA frameworks for ecological and human health risk assessment. The important first step in implementing this recommendation is to develop assessment endpoints and measurement endpoints which will reflect the assessment endpoints. As EPA guidance suggests, assessment endpoints should be developed through a consensus of several parties including the risk managers, risk assessors, government agencies, stakeholders, and potentially affected parties. In the present instance, these might include the local community, the TAG Committee, the Johns Pond Ashumet Pond Task Force, and the National Guard Bureau.

As indicated in this review, the agreed upon assessment endpoints will guide the ultimate field studies. The assessment endpoint should reflect the local value and uses of the pond. They are critical in determining the data requirements of an ecological risk assessment. For example, to answer the question "Are fish populations at risk due to exposure to toxic chemicals?" would require information on fish exposure and accumulation of chemicals. However, to answer the question "Are wildlife populations at risk due to exposure to toxic chemicals?" would require a different suite of measurement endpoints. The stakeholder should also identify and agree upon the current and/or future scenarios to be evaluated as part of a human health risk assessment.

We believe that the present data is sufficient to evaluate an assessment endpoint which addresses the trophic condition of the ponds on a site-specific basis. However, the NGB studies do not provide sufficient data to conduct site-specific human health and environmental risk assessments. By using actual physical, chemical, and biological conditions, a site-specific assessment reduces the uncertainty of the evaluation and provides important information for risk management decisions.

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 SUMMARY

Overall, we found the Ashumet and Johns Ponds Study reports lacking insofar as analysis and interpretation of the data were concerned. A considerable quantity of information has been collected and is provided in these reports. However, the reports are primarily a recitation of the data. Many of the analyses recommended by the Johns Pond Ashumet Pond Task Force have not been completed and the spirit of the Task Force's recommendations—to develop a good understanding of the potential effects of the MMR on the ponds—has not been fulfilled.

We believe that the data collected during this study provide a good basis for assessing the risk of eutrophication in the two ponds and additional data analysis should be completed to develop such an assessment. There are significant gaps that would need to be filled before site-specific ecological and human-health risk assessments could otherwise be completed, however. The data provide a basis for preliminary risk assessments, which are included in the AVGOU and SERGOU RI reports. However, the RI preliminary risk assessments were not based on community input and therefore did not define appropriate assessment endpoints that reflect the community's concerns. In this respect, a singular omission from the AVGOU preliminary risk assessment is the evaluation of the ecological risk of eutrophication of Ashumet Pond due to the intrusion of phosphorus from the sewage treatment plant plume.

We believe a risk assessment based on community participation is essential to addressing the concerns of the community. A particularly critical step in such a risk assessment is the definition of assessment endpoints. Assessment endpoints are a direct reflection of the aspects of the ponds it is desired to protect, for example, sport fishing, swimming, and water-quality aesthetics. Under the current EPA risk assessment protocol, assessment endpoints are developed cooperatively with the input of the community, government agencies, responsible parties, and other potentially affected parties. Such a process, and any necessary follow-up data collection, is essential to the successful completion of the Ashumet and Johns Pond Study.

The 1994 Annual Report does not indicate whether further investigations in Ashumet or Johns Ponds are planned. This review has identified several likely deficiencies in the data that may create a need for further field studies. We recommend, however, that such data gaps be identified in the context of a systematic risk assessment framework in accordance with U.S. EPA guidelines as discussed in this report.

Aside from data collection to fill specific gaps, long-term monitoring is required in light of potential future changes in the ground-water system. This need is particularly critical for Ashumet Pond for two reasons. First, the AVGOU RI indicates the potential for the FTA-1 plume to discharge to the pond in the future when ground-water remedial actions alter flow patterns. Second, elimination of the sewage treatment plant discharge creates the potential for enhanced transport of phosphorus to the pond in the future.

Long-term monitoring is recommended for at least two key environmental parameters: the quality of ground water migrating into Ashumet and Johns Ponds, and the trophic state of Ashumet and Johns Ponds. Monitoring of ground water is an implicit action under the continuing investigation and remediation of the MMR, but the community should seek specific assurances that such monitoring will be done as well as specific plans for the monitoring program. Monitoring the trophic state of the ponds can be done relatively inexpensively by limiting the program to key trophic state indicators (total phosphorus, Secchi disk transparency, and chlorophyll-a) at one or two stations in each pond. A monitoring program that favors regular (for example, monthly) sampling of these few parameters is likely to be more informative than irregular measurements of many parameters.

5.2 CONCLUSIONS

1. The Ashumet and Johns Ponds Study was completed by HAZWRAP for the National Guard Bureau following recommendations made by the Johns Pond Ashumet Pond Task Force. The Task Force recommended that data be collected to characterize ground-water quality, surface-water quality, surface-water sediments, storm-water quality, benthic algae, and chemical bioaccumulation in fish and mussels.

2. A Sampling and Analysis Plan was prepared by HAZWRAP to provide a detailed specification for the various measurements, samples, analyses, and other activities to be completed as a part of the Ashumet and Johns Pond study. The plan follows the Task Force recommendations closely.

3. The Sampling and Analysis Plan is comprehensive with respect to data collection but is generally deficient in specifying the types of data analysis to be done and how data analyses are to be reported.

4. The Sampling and Analysis Plan does not specify the completion of a risk assessment and does not incorporate current EPA guidance for human health and ecological risk assessment.

5. The number of samples and number of sampling locations specified in the Sampling and Analysis Plan for sediment are insufficient for site-specific risk assessment.

6. The Sampling and Analysis Plan does not include provisions to install seepage meters to collect pond-bed seepage although this was recommended by the Task Force.

7. Sediment and pond-bottom seepage data are significant because sediment and sediment pore water are the media in the pond in which volatile organic compounds are most likely to be detected. Volatile organic compounds are unlikely to be detected in surface water because they are diluted and volatilized and are unlikely to be detected in organisms because they do not bioaccumulate and are prone to loss by evaporation during tissue sample preparation.

8. The Sampling and Analysis Plan specifies that surface-water quality samples be collected quarterly in Ashumet and Johns Ponds. However, previous studies in both ponds had showed that algal populations and trophic state indicators vary significantly over time scales of weeks and months. The quarterly data captures these variations poorly which diminishes the value of the recent data for making comparisons with the earlier data.

9. The Ashumet and Johns Ponds Study is reported in quarterly reports with summaries in two annual reports. These reports are largely data compilations and provide only limited data analysis and interpretation. The reports are highly technical and would be unintelligible to many non-technical readers.

10. With respect to ground water the study concludes, and we concur, that contaminated ground water from the southeast MMR discharges into Johns Pond and the cranberry bog north of Ashumet Pond. The study does not discuss the discharge of contaminated ground water from the MMR sewage treatment plant to Ashumet Pond nor the potential for the Ashumet Valley Plume to discharge to Ashumet Pond as the result of future changes in the ground-water flow regime.

11. With respect to volatile organic compounds in surface water the study reports infrequent detections of trace levels of these compounds in Ashumet, Johns and independent reference ponds. The study concludes, and we concur, that pond surface water shows no evidence of contamination by volatile organic compounds from ground water.

12. With respect to conventional surface-water quality the study concludes that Ashumet Pond is somewhat more enriched with nutrients than Johns Pond but does not draw conclusions as to the overall trophic condition of either pond or any trends in trophic state over time. The study failed to carry through on the Task Force recommendation to construct a nutrient budget for each pond.

13. With respect to storm water quality the study concludes that pesticides and metals are present in storm water and could be the result of base activities. Our analysis of the concentrations found shows that they are comparable to typical urban storm water. Automatic storm water sampling equipment was specified by the Sampling and Analysis Plan but was not installed during the study, thereby limiting the ability to capture the most contaminated storm water that occurs during the "first flush" when a rainstorm starts.

14. With respect to pond sediment, organic compounds are found in sediment in both ponds. Contrary to the Sampling and Analysis Plan, the analytical results are not

compared to guideline concentrations from the MMR Risk Assessment Handbook. A preliminary risk assessment in the SERGOU RI finds that sediment may pose some risk to aquatic organisms due to elevated iron and other metals but not organic compounds.

15. With respect to benthic algae samples the study report indicates that the purpose of these samples is simply to provide a baseline against which future samples can be compared. This departs from the intent of the Task Force, which was specifically to compare benthic algae in the Ashumet Pond sewage plume discharge area with algae elsewhere in the ponds.

16. Although the study concludes that the data are insufficient to draw definitive conclusions, it reports no apparent differences in algal density or taxonomy between the discharge area and other sites in the ponds. The study also makes clear that this is an unexpected conclusion for which there is no satisfactory explanation. We believe more study is needed to clear up this question.

17. With respect to the fish bioaccumulation study, mercury and pesticides are detected in fish from both ponds. These compounds are ubiquitous in the northeastern United States and their presence at low concentrations does not necessarily imply the MMR as the source.

18. With respect to overall fish health, the study finds that fish health is poorer in both Ashumet and Johns Ponds than in other Cape Cod ponds sampled for reference purposes. Brown bullhead catfish are found to have a high incidence of oral and body surface papillomas and liver damage is found in some individuals of several fish species. The report states that "none of these observations can be conclusively linked to either environmental contamination in general or MMR in specific," but concludes that the environment of Ashumet and Johns Ponds is significantly different than in the reference ponds.

19. An independent study by the Woods Hole Oceanographic Institution study attributes catfish papillomas to a virus and not environmental contaminants. We

recommend additional study to confirm this conclusion because it is based on a limited experiment.

20. The study of chemical bioaccumulation in mussels was conducted only during the first year of the Ashumet and Johns Pond Study and discontinued for the second year without explanation.

21. With respect to volatile organic chemical bioaccumulation in both fish and mussels the study finds these analyses inherently inconclusive due to limitations in sample preparation and analysis techniques. We believe this finding could and should have been made during the preparation of the Sampling and Analysis Plan rather than at the conclusion of the study.

22. The final conclusion of the 1994 Annual Report on the Ashumet and Johns Ponds Study is "The data indicate no direct link between Base activities and contaminant concentration levels in either Ashumet or Johns Ponds." We believe this conclusion is stated with more certainty than is justified considering that contaminated ground water is discharging to both ponds and contributes a significant portion of the nutrient load to Ashumet Pond. The statement seems premature in the absence of an explanation for the fact that the overall health of fish in Ashumet and Johns Ponds is significantly worse than in reference ponds.

23. The information collected to date are insufficient to complete definitive site-specific human health and ecological risk assessments. Preliminary risk assessments included in the SERGOU and AVGOU RI reports indicate potential risks, but these appear to be based on conservative assumptions in the absence of sufficient data. More than anything, the preliminary risk assessments indicate the need for additional data collection within the framework of U.S. EPA risk assessment guidance.

24. Data required for a site-specific human-health risk assessment include additional shoreline sediment and surface-water sampling; characterization of potential human exposures; and further information on fate, transport, bioaccumulation, and toxicity of chemicals of concern.

25. Any future site-specific ecological risk assessments should involve community participation to define assessment endpoints. Assessment endpoints define the aspects of the pond that it is desired to protect.

26. Data required for a site-specific ecological risk assessment include supplementary sediment and surface-water sampling; background information on chemical toxicity, bioaccumulation, and persistence; identification of plant and animal species and habitat; and benthic macroinvertebrate sampling.

5.3 RECOMMENDATIONS

5.3.1 Completion of the Ashumet-Johns Ponds Study Report

The following are recommendations for consideration by the Ashumet-Johns Pond TAG Coalition Committee. These recommendations address finalizing of the Ashumet and Johns Ponds Study and completion of a risk assessment.

- The National Guard Bureau should be encouraged to prepare a summary report that emphasizes analysis and interpretation of the data collected during the Ashumet and Johns Pond study. This report should finalize the study conclusions and incorporate any newly collected data. Included in the report should be the quantification of chemical and nutrient loads to the ponds, comparisons with historical data to discern any possible trends over time, and identification of data gaps and additional data needs. Finally, the report should provide clear conclusions for each of the areas of community concern originally identified by the John's Pond Ashumet Pond Task Force.

- The National Guard Bureau should be encouraged to complete a systematic risk assessment in accordance with U.S. EPA guidelines. The risk assessment should include community participation in the definition of risk assessment endpoints to ensure that those endpoints properly reflect community concerns. To the extent that the risk assessment process indicates gaps in the existing data, those gaps should be filled. Areas in which additional data appear to be needed are further evaluation of the causes of oral and body surface papillomas on brown bullhead catfish, collection and analysis of seepage through the pond bottoms, further characterization of potential contamination of sediments and benthic macroinvertebrates, and further study of the effects of the sewage treatment plant plume discharge on benthic algae in Ashumet Pond.

5.3.2 *Continued Monitoring*

The following recommendations for consideration by the Ashumet-Johns Pond TAG Coalition Committee concern continued and long-term monitoring of Ashumet and Johns Ponds.

- There should be a continuing program of ground-water monitoring in the areas where contaminated ground water flows into Johns Pond, Ashumet Pond, the cranberry bog to the north of Ashumet Pond, and the area between the ponds. The goal of this program is to assess the quality of the ground water discharging into the ponds as the hydrology and water quality of the ground-water system changes over time. Such changes are likely to be associated with the cessation of treated wastewater discharge at the sewage treatment plant and the initiation of various aquifer pumping and recharge systems as a part of ground-water remediation.

- There should be a continuing program of surface-water quality monitoring to assess the trophic state of Ashumet and Johns Ponds. At Ashumet Pond, the plume of sewage-contaminated ground water from the MMR sewage treatment plant is likely to undergo significant changes in ground-water chemistry over the next several years. This creates the potential to increase an already significant source of phosphorus to Ashumet Pond and accelerate the rate of eutrophication of the pond. Therefore, in addition to the ground-water monitoring recommended above, we recommend a program of regular monitoring of trophic state indicators. Although Johns Pond is less threatened, it provides a very useful baseline against which to compare the changes in Ashumet Pond.

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